THE JOURNAL OF ENGINEERING EDUCATION

ublished by THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

W SERIES
L. XXVI., NO. 10 | JUNE, 1936 | Subscription Price $3.00 per year
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Published by the Society for the Promotion of Engineering Education

Published under the Supervision of the Publication Committee.
D. S. Anderson, C. C. Williams, F. L. Bishop, Editor, University of Pittsburgh.
Published at Prince and Lemon Sts., Lancaster, Pa.

Entered as second-class matter at the Post Office at Lancaster, Pa., under the Act of March 3, 1870.

New Series
Vol. XXVI, No. 10. JUNE, 1936 Subscription Price, $3.00 per year. Single Copies, 50 cents

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The keynote of this meeting, selected by President Anderson, has attracted an exceptional amount of attention not only among engineering teachers and practitioners but among others interested in education.

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The University of Wisconsin; its location; its eminence as an educational institution; its exceptional facilities; all contribute materially toward a successful meeting.

The conferences which have been arranged by the various chairmen under the general direction of Vice-President Daggett promise a wealth of material in specific subjects.

The early appointment of official delegates from the various educational institutions indicates a wide interest by administrative officers in this particular meeting.

"On (to) Wisconsin."

CAN THE JUNIOR COLLEGE GIVE THE NECESSARY WORK OF THE ENGINEERING COURSE?

By WARD H. AUSTIN

Vice President, Marin Junior College

A survey of the aims, purposes, and functions of the junior college as set forth by such authorities as Koos, Eells, Proctor, and others, during the past decade reveals that the objectives of the junior college are: first, preparation for the upper years of a standard college or university, and, second, preparation for direct entry into occupational life. In relation to engineering education the first or preparatory objective involves the problem of whether or not the junior college can give the necessary work of the Engineering Course.

Dean Sadler of Michigan * has stated that somewhere in the first, and possibly in the second year of an engineering course, some subjects must be introduced which will test the student's ability or aptitude for enginering, otherwise, if the discovery that he is mentally unfit is postponed to the third year, much valuable time will be lost. He recommends as desirable the inclusion of studies taken from the following groups.

(*a*) English and English Literature.
(*b*) History, Economics, and Foreign Language.
(*c*) Mathematics and Mechanics.
(*d*) Physics and Chemistry with Laboratory.
(*e*) Drawing and Descriptive Geometry.
(*f*) Mechanism or Shops.

These requirements are met in various extremes by our Pacific Coast engineering schools. In some cases little or no engineering work is offered during the first two years, in other cases a considerable amount is required. Junior colleges are left the choice of the line that they should follow. This is generally decided for them by their student group. Of the 150 engineering students in surveying courses at Marin Junior College during the past seven years only seven had any other course in view than that of the University of California. Unfortunately or otherwise they have not all been able to go on. Judging from the bulletins of some thirty-six junior colleges in California this condition exists through-

* "Curriculum in Engineering Schools," University of Chicago Press, 1929, Vol. 1, p. 99.

out the state. Therefore it would appear that, at least for the present, the scholastic requirements to be met in the lower division of the engineering course are those of the University of California. I should like to describe briefly how these requirements are met by the Marin Junior College and to indicate the cost of the operation. As the present year is about average so far as enrollment is concerned, the figures used are for 1934–35.

The engineering courses requiring equipment consist of chemistry, physics, geology, surveying and mechanics shop. In the case of chemistry and geology there are about as many of the non-engineering type of students as there are engineering students although in chemistry the two groups are separated both in lecture and laboratory sections. In physics four-fifths of the group consists of engineers. A general course is offered for other students but as they use the same equipment, and little of that, the laboratory is equipped with the engineering group in mind entirely. In surveying the entire expenditure has been made with the idea of meeting the requirements of the engineering course, although many of the group take the course for the material rather than as a requirement for transfer. It is one of the few technical courses of value to students not planning on transfer to a higher institution. The mechanics shop as given at Marin closely parallels the work of Mechanics 10 at the University of California with probably considerable more work in welding and metallography being included. This is possible on account of smaller classes and, in the case of metallography, more equipment per student. This equipment also does double duty in that it is used in connection with our materials course.

A recent inventory brings forth the following information: Chemistry equipment $4,000, cost of materials for the year $500; Geology equipment $500, consisting mainly of a petrographic microscope, cut off wheel, polishing equipment, materials and specimens; Physics equipment $10,000, adequate for experiments in mechanics, heat, light, sound and electricity; Surveying equipment $3,500; Engineering shops $10,000, consisting of basic machine tools, Universal testing machine, microscopes, hardness tester, electric welder, acetylene welding equipment, pattern making tools, and molding equipment for non ferrous metals, automatic furnace controller and electric furnace for heat treatment experiments. This equipment, purchased new during the past seven years at a total cost of $27,500, is considered necessary to meet the requirements of the engineering course. It is adequate for a class of 40 students per year with the present teaching staff. A larger number of students could be accommodated by the same equipment with an increase in the number of instructors.

The engineering staff at present consists of four instructors, three with the Degree of Master of Science, and one with a Degree of Doctor of Philosophy with a major in physics. Two have had several years of engineering experience before going into teaching and three have had teaching experience before coming to the junior college. Salaries of the instructors are far above the average to be found in the general run of lower division work in engineering schools.

In a junior college four or five instructors on the average are associated with a student as compared with ten or more in our larger four-year engineering schools. Fewer instructional contacts promote the well-being of the student for a teacher who has a student in more than one course can more ably advise and assist him. In larger institutions the absence of individual contact necessitates complete emphasis on subject matter without regard to the needs of the individual student.

Ordinarily a student entering a university at a distance from home has to make two fundamental adjustments at one time. One is the adjustment of learning to study away from the school on his own initiative, the other, the adjustment of living away from home, often under conditions and contacts which are none too good. Some students are able to make the adjustments with ease, others just barely make them, while 40 per cent fail entirely. A student entering a junior college has only one of these adjustments to make for he is generally living at or near home. Since the campus is openly at war with scholarship, a junior college offers fewer distractions.

The teaching is often better in the junior college. There appear to be two distinct types of teachers. The Research Type, interested only in subject matter, belong in the upper division where skill in presentation is less important, for students have attained sufficient maturity to pursue their studies independently with some success. The second type of teacher is interested primarily in the individual student's success. His field is in the lower division or in a junior college. It is unfortunate that in many cases the four-year college freshman and sophomores are taught by the least experienced teachers, as it is the ambition of successful professors generally to teach in the last two years at college or in the graduate school.

In the JOURNAL OF ENGINEERING EDUCATION for February 1933, Professor R. E. Davis, of the University of California, lists 7 objections to the fully qualified engineering student normally attempting to pursue the engineering curriculum of the first two years in a junior college.

1. The courses offered in many of the junior colleges are taught by instructors with little or none of the background of engineering experience.

This is true in many cases but is due in part to the fact that the Engineers have not the qualifications to meet the requirements imposed by the state and in part to the fact that it is a new field for the engineer. What of aviation and radio during the first ten years? They have all encountered growing pains. A rather brief study of the bulletins of thirty-two junior colleges in the state with respect to their engineering programs and instructors is of interest in connection with this statement. Fourteen junior colleges list the complete requirements for the lower division work in the college of civil engineering, seven list the complete work for both civil and mechanical engineering, twenty-three others attempt some work in civil engineering but in many cases it is handled by the mathematics and physics departments. In altogether too many cases the offerings, particularly in engineering, are inadequate to meet the university requirements as they now stand. In many cases the bulletins make no statement regarding the faculty of the school or whether they had one.

From a study conducted under Dr. Merton E. Hill the following general data are interesting in connection with the instructional staff of the California junior colleges. Of 948 cases studied, 21.2 per cent of the junior college instructors had a Bachelor of Science Degree, 7.81 per cent Master of Science Degree, and 5.17 per cent Ph.D. The majority of the teachers, 74.97 per cent, have had teaching experience in the senior high school. Less than one-fourth of the teachers, 21.31 per cent, have had experience in university teaching. Only 13.5 per cent of the teachers have had experience in college teaching. A very small number, 5.8 per cent, had taught only in the junior college.

It is my belief that a survey should be made in order to determine exactly the training and experience of the engineering instructors in all the engineering schools of the state as well as in the junior colleges. Unfortunately my assignment came too late to attempt other than a bulletin study of the junior colleges, which is very unsatisfactory.

2. There is nothing about the smaller junior college of engineering flavor and furthermore the students do not have the opportunity to come in contact with engineers engaged in professional practice.

This statement can be very true. Our attempts to meet this situation at Marin might be of some value to other junior colleges and possibly of interest to our university friends. Due to the small number of students in each chosen field and to inability to be-

come even a student member in most of the professional engineering societies, a local Engineers Club was organized some years ago. A dinner meeting is held each month followed by an engineering program. This program is sponsored by the members themselves, reports being made on various engineering projects under way in the Pacific Coast. At times an outside speaker, an engineer or other prominent man, is secured. Two rather extensive inspection trips are made each year. At the meeting previous to the trip there is a discussion of the things to be seen and some preliminary explanations are given of the new equipment to be observed in order to enable the members to get full value from the trip. No written report is necessary or needed and the material and events of the trip tend to promote a morale among the members that does not exist in any other campus activity. Trips to Boulder Dam, the Big Creek System, Parker Project are some of the more distant projects that have been visited in the past. Due to our location, the bridges (San Francisco Bay Bridge and The Golden Gate) have come in for their fair share in the shorter day trips. Membership in the club is restricted to engineering students who have maintained a C average for one semester.

3. They do not have the opportunity of visiting engineering laboratories.

In some isolated cases this statement may be true. Many of the junior college engineering departments make organized trips through the various laboratories of near-by colleges and industrial concerns. A trip of that nature, under proper supervision and guidance, with a discussion before and after the trip, can be of value. The results of the casual trip through any laboratory are questionable. The student has not been sufficiently exposed to the engineering field, either in school or out of school, to gain from such an experience. University Campus Engineers' Days have attracted thousands of high school and university students. Invariably the spectacular demonstrations will be well patronized, whereas a project requiring even the simplest technical explanation will probably be attended by a few upper class students who can appreciate what is going on. The student in charge of the demonstration profits by his experience, but these privileges naturally come within the realm of the upper classmen.

4. The student acquires no professional consciousness.

Can professional consciousness be acquired in the first two years in any professional field? One prominent educator said with regard to this statement that the students probably thought they had more at the end of the first two years than they had after the third and fourth. Professional consciousness can be developed only through specialized courses and material of the particular field. Prac-

tically every student is in a junior college taking advanced mathematics, physics and chemistry in the engineering group, whereas, particularly in the larger engineering schools, they are one of a group of five or six sections in say mathematics or chemistry, with nothing distinctive in any section. In the junior college they get the class mark earlier, they have more opportunity of asserting themselves. However, professional consciousness can better be developed in the upper division or graduate school.

5. In a large number of cases it is necessary to spend a fifth year.

Is this due to the junior college? Probably in some cases where the offerings have been inadequate during the first two years it is. What of the many students who go directly to the four-year type of engineering schools and stay on for a fifth year? Dean Rodman of the University of Virginia has stated that we owe to engineering students whatever may be given to them to serve them, not only in their general technical field, but in the equally important field of good citizenship, including a helpful background on which they may develop in a worthwhile way the greater amount of leisure which seems inevitably about to become a part of life for most individuals of the future. It is doubtful that their complete program can be covered in a normal four-year curricula. Why not admit it when they register instead of letting them find it out soon enough. In fact this tendency to stay on is reflected in the tendency to remain after graduation. With the increase in complexity of engineering work, with the extensions that have come in the field of engineering in recent years, post graduate work is assuming greatly increased importance. Dr. Walton C. John states in The Journal of Engineering Education for November, 1932, that in 1921–22 there were 368 graduate students in the engineering schools of the country, while in 1925–26 there were 1,114, and in 1930–31, 2,939, or an increase of 700 per cent in nine years. In view of this the complete validity of the report of the Board of Investigation and Coördination of the Society for the Promotion of Engineering Education approving the adequacy of a four-year engineering course is open to question.

6. The student is ill advised.

A large share of the advising of students in a junior college falls to the lot of the instructors in orientation courses.

Probably no two courses follow the same track, and Mr. Mohr of Marin Junior College reported, "Here is what I did this year, but I expect to change it some before another year." In general, however, his outlines for the past three years cover considerably more advising than the average engineering school freshman encounters. The course consists of one lecture and one section meet-

ing each week. A special section has been arranged for the prospective engineers. The books used include—text, O. H. Werner's "Every College Student's Problems," Pitkin's "Art of Rapid Reading," and "New Careers for Youth," "The Technical Man Sells His Services," by Hurst.

The following topics are studied and discussed in detail in section meetings.

1. Rules and Regulations of the junior college.
2. Use of Library. Time schedule for study hours.
3. Laws of learning and special applications to study.
4. Making of notes.
5. Examinations.
6. Requirements for graduation from junior college and transfer to other institutions.
7. Junior college organization and standing.
8. History and present status of universities.
9. Place of junior college in educational system.
10. Comparison of modern United States and European system.
11. Honorary and earned degrees.
12. Preparation for final examinations.

In addition to the orientation courses some junior colleges offer their engineering students a course listed as a survey of the engineering fields. This course includes a discussion of the upper division and graduate courses of the engineering schools in the state, the field of work so far as such segregation is possible, professional engineering societies, engineering publications, placement and remuneration, and in many cases, simple problems in each field.

7. It has been said that junior college students do not have the opportunity to come in contact with more advanced students.

Dean Lovell of Michigan has made an interesting statement regarding this apparent fault which is particularly applicable to the departmental type of junior college. "The prolongation of the high school regime, particularly if the junior college continues in the high school building, retards somewhat the growth of manly responsibility and maturity. The high school 'play boy' attitude persists over long and many evidences of infantile behavior greet the eye which would be checked instantly in the university by the grave old senior's stern command of 'fresh out.' Certainly the younger students may learn much in the ways of social life and graces from the upper classmen and in the cosmopolitan make-up of their associates, lits, engineers, laws, medics, educators, etc., they may find revealed values in fields which they have not thought of before."

This is an ideal condition, however, and not so apt to occur as it is desirable. However, in a junior college the student has more direct contact with the instructors, whose opinions and advice concerning academic and professional matters should be somewhat broader than those of students who are taking, or have just completed, the course.

Some of the junior colleges of this state are successfully meeting the requirements of the engineering course. Your publication, the JOURNAL OF ENGINEERING EDUCATION, contains favorable reports from other states. From Michigan Dean Lovell reports, "because of the very cordial and effective coöperation prevailing between the junior and senior colleges, the junior colleges have adopted the same admission requirements as those of the university, and their programs of study and individual courses in the academic schedules are closely related to those of the senior college, so that there is precise continuity in the development of the full program. With these admirable arrangements, it has been our experience that the junior college graduates come to the University well prepared, they have no great difficulty in making the new social adjustment to life in the larger senior college, and in general they continue with their studies in a very satisfactory manner."

John Hedberg,* Instructor in Civil Engineering at Stanford University, reports, "that junior college transfers compare well with our regular Stanford men." It is his opinion that they can hold their own in the junior year of any of our universities although he states his observations as limited to teaching of advanced engineering in but three, Cornell, Purdue, and Stanford.

From recent studies by Doctor Merton E. Hill, University of California, "A Study of Admissions," or maybe we can say Admissions by the University:

"In order to trace the effect of both subject and scholarship preparation in high schools, the records of 5202 junior college transfers in six Phi Beta Kappa Colleges in California have been examined. Chart III, page 50, of this represents the cumulative grade point ratio of these transfers.

Institution	No. of Transfers	Average Grade Point Ratio
A	2,620	1.12
B	1,492	1.11
C	301	1.37
D	142	1.34
E	376	1.56
F	71	2.01

Although the cumulative grade point ratio of 'native' students of similar status at the university is approximately 1.34, yet (and

* *Junior College Journal*, March, 1933, p. 310.

please note this) the achievement of the transfers at higher institutions is remarkable, for approximately only 50 per cent of them were qualified for admission to college upon the high school graduation, yet these transfers made higher than a C average at each of the institutions attended." There are other very interesting data from Dr. Hill's report which I believe junior college instructors should note, and I should like to quote again further from this report. "The cumulative records of 182 Junior College transfers admitted to the University of California during 1931 with approximately a C average. No transfer (in this group) had more than 10 excess grade points in the courses presented for entrance to the university. The first group of 141 transfers averaged 5.9 grade point deficiencies during their first semester, while the second group of 41 transfers averaged 2.75 grade point deficiencies their first semester at the university. Clearly junior college transfers who wish to maintain a satisfactory average in the university should maintain a C plus average in the junior college."

A comparative study of the achievement of junior college transfers in certain subjects made by Henry W. Stager at Stanford University and published in the *California Quarterly* for June 1934, brings out the facts that in engineering subjects the mean grade point ratio for the native Stanford student is 1.66, the junior college transfer 1.69, and the transfer from four-year colleges 1.53.

Summarizing, we have found that the junior college may so organize its staff and work as to make invalid most of the reasons why the fully qualified student should not pursue the engineering curriculum of the first two years in a junior college. The reasons advanced, which by the nature of the two-year school still stand, are, I believe, offset by advantages peculiar to and inherent in such a school.

Statistical data which have been compiled on the comparative scholastic achievement of junior college transfers to four-year schools, prove that the achievements of junior college transfers compare favorably with those of native students.

It is my belief, therefore, that the junior college can give the necessary work of the engineering course.

THE ENGINEERING CURRICULUM IN THE JUNIOR COLLEGES *

By TRUMAN D. THORPE

Instructor in Engineering, Sacramento Junior College

The engineering curriculum discussed in this paper includes, and is limited to, the civil, mechanical, and electrical curricula prescribed for those students entering junior colleges with the objective of completing their engineering education at a standard four or five year engineering college. By "non-recommended" students is meant those students whose high school records are such that they cannot be admitted to full freshman standing in engineering at the University of California.

Three important but distinct factors must be considered in designing the junior college engineering curriculum. First: a majority of the graduates in engineering do not definitely decide the university which they will attend until the last year of their attendance at junior college. Second: about twenty per cent of the engineering graduates, for financial reasons, find it impossible to complete their education at a university and most of these seek employment in some semi-professional field of engineering. Third: a great percentage of the entering students (seventy-five per cent at the Sacramento Junior College) are "non-recommended" students.

It seems essential, therefore, that the junior college engineering curriculum prepare the student, on graduation, to enter any university that he may desire; that it give the graduate as broad a foundation as possible in engineering fundamentals and general education; and, that it compel the "non-recommended" student to strengthen his foundation so that he may successfully continue his engineering education. In addition it seems desirable that it offer a pre-view of some of the hurdles he will encounter during the first semester of his attendance at the university.

The engineering curriculum of the Sacramento Junior College has been designed to fulfill the above requirements. For a number of years we permitted all entrants with the necessary prerequisites (regardless of high school grade) to enter the difficult two-year curriculum with the inevitable result of a high percentage

* Presented at the meeting of the Pacific Southwest Section, Stanford University, December 27, 28, 1935.

of failures. We finally came to the conclusion that we were undertaking an impossible task in trying to prepare, in two years time, the "non-recommended" student for entrance into his junior year at the university. In 1930 we decided that only "recommended" students would thereafter be eligible to enter upon the regular two year curriculum. All other students were required to complete, in their first semester of attendance, a five unit review course in advanced high school algebra and plane trigonometry before being allowed to enter the two year course in engineering mathematics. This automatically placed all of the "non-recommended" students in a three-year curriculum. During the first semester these students were also enrolled in surveying and engineering drafting so that they might obtain an idea of the field they proposed to enter and of the standards they would be expected to maintain in their future engineering courses. Extending the course to three years also provided the students with the opportunity of exploring fields unrelated to engineering, with the resultant broadening of their general education. The opportunity was also afforded us to introduce into the curriculum courses intended to extend, as much as possible, the graduates' knowledge of engineering fundamentals, and at the same time give them an introduction to some of the subjects they would encounter in the junior year at the university.

As a doctor inoculates his patient against a dreaded disease, we decided to immunize (as best we could) our students against the mortality of the "Strength of Materials" and "Engineering Mechanics" courses to which they would be exposed as soon as they reached the university. The "vaccine" used is a year course of two semester units designated in our curriculum as "Elements of Engineering" and required of all engineering students in their last year of attendance at junior college. It covers the elementary principles of "Strength of Materials" and "Engineering Mechanics" presented in the same manner and with the same high standards that these courses are presented at the university. While no specific data are available to us, our students report that this course has proved of great help to them during the first semester of their junior year.

Dependent upon "Elements of Engineering" are two additional courses which we believe of great value to those who do not continue their education at the university. The first, "Structural Drafting and Design" is a year course of two semester units designed for those students who desire to become draftsmen in civil engineering. The second, "Machine Drawing and Design," is a semester course of three units for draftsmen in mechanical engi-

neering. Each of these courses involves the practical application of the principles covered in "Elements of Engineering."

The results of the three year curriculum have been studied from the records of the classes entering in 1930, 1931, and 1932. Thirty-four per cent of the entrants of these three classes were graduated in engineering from the Sacramento Junior College. Twenty-seven per cent of the entrants of these three classes graduated from or are now in their upper division work in a four year engineering college. Forty per cent of the latter were in the "non-recommended" class when they entered junior college. When the material with which we work is considered, I believe that the above percentages compare very favorably with the thirty-five per cent graduated in engineering by the four year college. It might be interesting to advocates of the five-year engineering curriculum to note, at this point, that of twenty-nine "recommended" engineering students now in attendance at the Sacramento Junior College, twelve elected a three-year curriculum in order that they might have the opportunity of exploring fields other than engineering, and but five are enrolled in the strictly technical two-year curriculum. I believe that this may be explained by the fact that the student residing at or near home, feels that he can afford the time to broaden his educational background.

After a trial of five years, I believe that the extension to three years of the lower division engineering curriculum has produced excellent results. I feel sure that like results could not have been obtained had the "non-recommended" high school graduates been required to make up their high school deficiencies before starting their engineering courses. The immediate induction of the student into some of his practical and theoretical engineering courses produces one of two results, either he feels that he has entered upon his career and thus takes a more mature and serious view of his work, or he finds that engineering does not appeal to him, and he leaves it for fields more fitted to his talents and energies. I believe also that the close personal contact between the student and his engineering instructor, which is impossible in the lower division at the large universities, is a vital factor in determining his success or failure.

We admit our urgent need of semi-professional curricula in engineering as an outlet for a large portion of our engineering students who have their minds fixed on following an engineering career but who, at the end of one, two or three semesters, find themselves incapable of continuing successfully with the professional engineering courses. We hope that the time is not far distant when our district can finance such a program. An outlet for these students would save for the community a large number of

trained men and would prevent, for many students, the disillusionment and heartbreak which accompanies failure to achieve a fixed ambition.

Discussion

Raymond E. Davis: It is generally recognized that in the training of students in the fields of Engineering, the junior college has a dual objective; first, to train for a vocation allied with engineering those students who for one reason or another will not go on to the university; and second, to offer lower division training in fundamental engineering subjects which will enable the engineering student to carry on successfully upper division work within the university.

In presenting the 3-year curricula in civil, mechanical, and electrical engineering at Sacramento Junior College, Mr. Thorpe has this dual objective in mind. But my experience would lead me to believe that this dual objective cannot be attained by any single curriculum.

It seems to me that in establishing curricula in the junior college we must keep in mind the capabilities and needs of two different types of student. Falling into the first and larger group are those whose engineering aptitude is in the direction of the manual. They like to deal with concrete problems, with things that they can see and feel. They are our future technicians and builders. They have little aptitude for what may be termed the "science" of engineering, but may possess great aptitude for what may be termed the "art" of engineering.

In the second and much smaller group fall those who have the intellectual capacity for scientific reasoning and who have the ability and the imagination to cope with problems which are more or less in the abstract. These are our future professional engineers, our designers, and our researchers.

To attempt adequately to train these two groups by a single curriculum is like trying to mix oil and water. For a great many years the engineering colleges of the country have been attempting to train all of their students on the upper, or professional level, and the results have been disappointing. This has been necessary because those who possess aptitudes for engineering work in the lower levels had no other place to go. So far as engineering is concerned, the junior colleges could perform no greater service than to offer adequate training on this lower, or semi-professional, level; for there is real need for draftsmen, inspectors, foremen, and technicians in the field of industry. And it is quite reasonable to expect that the training in this field should extend over a period of three years beyond the high school.

But, to my mind, the type of training must be quite different from that offered by the lower division of our universities; and courses in the fundamental subjects such as mathematics, physics, and chemistry must be more closely tied up with the practical. In other words, they must be so given that their usefulness as tools will be immediately apparent. They should be offered with breadth rather than with depth, and should deal with concrete problems in technical fields. For a student of the manual type the intricacies of differential and integral calculus have neither educational nor vocational value.

Considering the professional group, it is obvious that rigorous training in the fundamental sciences, including mathematics, physics, and chemistry, now offered during the first two years, is the essential foundation for engineering work on the professional level. To extend these first two years over a 3-year period by the addition of so-called exploratory courses which are on the semi-professional level, is as educationally unsound as it is to force students of the manual type to take the more rigorous courses in mathematics, physics, and chemistry.

Moreover, it seems to have been conclusively demonstrated that to train professional and semi-professional students in the same class is inefficient and ineffective. With mixed classes it is impossible to maintain a grading standard which will do justice to students in both groups.

One other matter is deserving of consideration. In the curriculum proposed by Mr. Thorpe, which is now in effect in Sacramento Junior College, the lower division training extends over a period of 3 years rather than 2 years. Obviously, even if professional and semi-professional students were separate, this makes it easier for the professional student. In other words, he does not have to work under as great pressure as if he had to cover the same ground in 2 years, and he learns to take things easy. The result is that when as a junior he enters the upper division of the university, he suffers a terrific jolt!

Over a period of years records have been kept of the scholastic achievement of student transfers to the University of California from various junior colleges within the state. A study of these records is illuminating.

Year after year those institutions having separate professional and semi-professional engineering curricula and separate classes for professional and semi-professional students consistently send us transfers who do satisfactory university work. On the other hand, those who do not offer separate curricula or separate classes for professional and semi-professional students consistently send us transfers who do unsatisfactory university work.

To emphasize this statement, I have the records of two junior colleges from each of which there came during the period under consideration more than 400 transfers. In Junior College A, where there were separate curricula for professional and semi-professional students and where there was group segregation, the grade-point average attained by transfers after entering the university was 1.37—the same grade-point average as that maintained by students who entered the University of California as freshmen.

For Junior College B, where there was a single engineering curriculum for all students and where there was no segregation between professional and semi-professional groups, the grade-point average attained by transfers after entering the university was 1.07.

A great deal has been said about the advantage of small classes in the junior college and the individual attention given to students who at the time of high-school graduation were ineligible to admission to the University of California or other comparable institutions. It has been stated frequently that this personal attention to those in the ineligible group has made it possible for many to carry on upper division university work successfully. There are individual cases where this is true; but by and large, the high-school record of a student is a pretty good indication of his ability to do university work. And while in the case of the University of California it is true that a great many enter the upper division who were ineligible for admission at the time of high-school graduation, the percentage of fatalities in this group is very high, particularly from those institutions where no attempt is made to separate those who were ineligible at the time of high-school graduation from those who were eligible.

To emphasize this point, I will take up the cases of the two large institutions just mentioned. From Junior College A, offering professional and semi-professional curricula and separating students into professional and semi-professional groups, the grade-point average attained by those who were eligible for admission to the University of California at the time of high-school graduation was 1.53, and the grade-point average of those who were ineligible at the time of high-school graduation was 1.28. For Junior College B, offering a single curriculum for all engineering students, with mixed classes, the grade-point average attained after entering the University of California by those who were eligible at the time of high-school graduation was 1.28, and by those who were ineligible at the time of high-school graduation was 0.80.

EDUCATION AND ENGINEERING

By R. L. SWEIGERT

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It is always interesting to note relationships, real and otherwise, that seem to exist between engineering and education. The reactions of many scientists and engineers are also interesting whenever education, from the viewpoint of the college of education, is mentioned.

Unquestionably there are plenty of faults to be found in colleges of education. There are also plenty of faults to be found in colleges of engineering. It has seemed to me that the adoption of a "holier than thou" attitude on the part of some scientists and engineers in relationship to colleges of education is something to be avoided. I have had experiences in both engineering colleges and colleges of education. I see no fundamental difference between the two. It has appeared to me that the scientist and engineer is very likely to form his opinion of the college of education on the basis of such cases as those mentioned by Mr. Rose in the April issue of the JOURNAL.

I am not defending colleges of education, nor am I defending all their practices, but merely because certain things occur which may be soundly condemned is no reason for condemning everything concerning these colleges.

There are things, in the college of education, from which engineering educators can profit. I do not propose to discuss all these items in relation to engineering education, as such a discussion would be beyond the purpose of this article. I would like to point out, however, that for the engineering educator, particularly the younger ones, educational philosophy, educational psychology, educational statistics, tests and measurements, student personnel problems and procedures, and perhaps a little study in fundamental curriculum construction and supervision would be of benefit. Even a course on secondary education would be of benefit to some who do not seem to have any sympathy with, nor understanding of, problems of secondary education. This is of value because our raw material comes from the high school. Also, if we are prone to criticize, the criticism may be worthwhile and not worthless, as a considerable portion of it is now.

Upon analysis, most discussions involving colleges of engineering and colleges of education may be centered upon two points of

emphasis, the one being on subject matter, and the other, on the human element, the student. There are still too many engaged in teaching who underrate the importance of the student. The emphasis of the college of education, if it is a good college, is on the student, as it should be. However it does sometimes forget the importance of subject matter. There is no question on the point of subject matter in so far as engineering colleges are concerned. The engineering teacher must, first of all, thoroughly know his subject. But that is not sufficient. He should be thoroughly familiar with the student and all that concerns him in the educational process. A first-class job of educating prospective engineers cannot be done unless the subject matter and the student are joined together through a process of stimulated thinking. The fact that so small a proportion of our engineering graduates can really think is a situation of which no one can be proud. Proper consideration of the student will help. The college of education can contribute to this end if we will let it. We should not condemn the whole college of education because we do not like some parts of it.

I do not think that engineering schools, as a group, need to worry about arbitrary standards being imposed by colleges of education. Junior colleges are in a different position, however, because in many cases the junior college may form a part of a local school system, in which part of the faculty may serve both the high school and the college, and the administration, in some cases, may be the same.

It appears to me at present that the semi-technical training (two-year terminal course) given in the junior college is in about the same position as vocational education at the senior high school level. In the vocational education, with which I am familiar, those trained in education, who are administering this work, have generally employed men who, first, knew their subject, and then second, who had the necessary educational training. I have seen men employed who could meet no educational requirements, but who naturally were required to make up this requirement through extension courses or summer work. No fault can be found with that attitude. The subject matter came first but the student also received attention. I am not implying here that engineering teachers should be required to have a certain number of credits in education. They should not be required to meet any such arbitrary standards now or ever. I mentioned the above to show that there are a great number of men, educationally trained, who favor the same thing that engineering teachers do. I might also mention a law passed in one state, that required those who taught subjects in the high school to have a minimum number of hours in the subjects that they

proposed to teach. This law barred many from teaching, but it resulted in an improved situation. This law was fostered and put through by those educationally trained. I could mention more cases. There are men trained in education, and there are men in colleges of education who think as we do in regard to subject matter.

If the engineering student occupied a more favorable place in the mind of the engineering teacher, and if the way a student actually learns, if the way his thinking and understanding are developed, and if the way this student training is put into action by the student, were better understood, our curricula would not be cluttered up with a number of courses to which students are exposed, and more attention would be given to individual course content and method. It is surprising how many feel that they have accomplished a particular thing by adding a course to the curriculum. In order to be fully effective, life situations must be brought into the college training and the student must go through these life situations himself. He must participate, and participation does not mean memorizing the notes from some professor's lectures and handing back the same information in tests, with the result the student receives an A, and little education. An intelligent study of pertinent educational subjects should help improve the situation.

It might be mentioned, finally, that when one does study educational subjects, as in studying any subject, the good that one receives depends upon his own efforts, upon his own ability, and upon his own background as an aid in interpreting what he studies.

Let us, as engineering educators, have open minds and use those things from the educational colleges that will help us to do a better job in engineering education.

METHODS

By JOHN C. PARK

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Foreword

In so far as the writer has been able to ascertain, not much has been written on the subject of engineering teaching, except that contained in the Publications of this Society.

Consequently, this paper can be little else than a chronicle of the writer's own observations, experience and opinions, with perhaps a few ideas obtained from some long forgotten source.

Methods

It was twenty-eight years ago last September that a professor in the Warrensburg Normal School began the first lecture of his course, "Methods in Geography," with the statement that the best method is to know your subject. This was the first time the writer had heard such a statement, but not the last, and the end is not yet. What does it mean?

Does it mean that the most important prerequisite of an instructor is knowledge of his subject? Does it mean that an instructor, thoroughly conversant with his subject, need give no thought to his method? The statement is ambiguous. Knowledge of a subject has nothing to do with method. Knowledge of a subject is assumed as a starting point for the discussion of method. The method used will depend upon the objective of the course.

Knowledge of a subject is important. In the very nature of things the instructor's knowledge of a subject will increase with each year of teaching. This is not true of his method. Method tends to atrophy with each succeeding year unless the instructor is impressed with its importance and continuously strives to improve it.

When an instructor has become thoroughly conversant with his subject in all of its implications, he can then do nothing else but improve his method if he wishes to increase his teaching effectiveness. Profound scholarship is not enough. Methods must be studied.

Some cases have been noted of men who have delved into the higher phases of a subject to the extent that they have lost interest

in its more elementary phases, have lost patience with the immature minds of elementary students and are rated as poor teachers. They are poor teachers, not because of the extent of their knowledge but because they consider method of no importance and give it no thought.

There is no one best method. Obviously, the best method for one student will not be best for some other. It is axiomatic that in handling men, the natural leader, the driver, and the quiet diplomat may get good results, each in his own way, but should one try the method of the other, he would succeed only in making himself seem foolish. Likewise, in teaching, the method should conform to the individual characteristics of the instructor.

Methods may differ but, to be successful, they must all accomplish the aim of the course. If the aim, in a specific course, is to develop the power to reason, a method should not be chosen which will encourage the student to memorize the subject matter and to record it on an examination paper without knowing what it means.

The approach to any successful method must begin with the instructor's attitude. The attitude should be one of ambition, determination and sympathy. An instructor should be fired with the ambition to increase his effectiveness with each succeeding year. He should be able to say each year that he has raised his standards, increased the content of the course or decreased his flunk list. He should be determined to make his teaching effective at all hazards. In spite of inadequate prerequisites or poor mental capacities of his students, he should be untiring in his efforts to give them an adequate grasp on the subject in hand. He should be determined to overcome the students' laziness by creating such an interest as will make the students put forth their best effort. Furthermore, he must make them understand that, no matter how poor the teaching, they can master the course if they have the will to do so. Failure rests on their own doorstep. The instructor should also be sympathetic. He should realize that the student is the son of his employer, the taxpayer, and that the father is probably greatly worried about him. It is not amiss to ask, "What would I do with this dumb fellow if he were my own son."

Objection may be raised that students are given too much help; that there is too much "spoon-feeding"; that all students must be self-educated, etc. It should be remembered, however, that the instructor's job is to train students, not merely to teach subjects. Until the student is so trained that he needs no further guidance, the instructor's job is not completed.

If the instructor blames himself for the failure of his students, the number of failures tends to decrease.

As the method chosen must depend upon the objectives of the course it will be pertinent, before proceeding further with the discussion of method, to examine the aims and purposes of college teaching. The primary aim of any particular subject is usually obvious. The general aims and purposes of a four-year course in engineering are not so obvious. They may include more than the mere sum-total of the specific aims of the several subjects. There are certain aims and purposes which should be common to every college course.

It may be of interest to note here some ideas taken from the book, "The American Arts College."* Among the several recorded presentations of The Aims of the College of Arts and Sciences was found the following:

"1. Preparatory: Supplementing the work of the lower schools, a college education should give possession of such tools of learning as will make the pursuit of necessary study both in college and throughout life both pleasant and effective.

"2. Cultural: In preparation for the non-vocational life, a college education should secure: (*a*) The possession of such an appreciation of one's own responsibility for social progress and such an attitude toward study as will most nearly assure a scholarly examination of social situations as they arise in life. (*b*) The possession of such information, social experience, and aesthetic appreciation as will most nearly assure judgments, both intellectual and moral, in accord with modern social demands. (*c*) Self-mastery such as will most nearly assure behavior in conformity with one's judgment.

"3. Vocational: (*a*) So far as it can be given more effectively and economically in college than in apprenticeship, the college should afford such knowledge and skill in those vocations, success in which depends to a marked degree upon general culture, as will most nearly assure successful pursuit of the given vocations with a minimum term of apprenticeship. (*b*) In connection with those vocations calling for highly specialized curricula, the college should afford those general studies which are basic for the specialized curricula but which are not in themselves specialized to any considerable extent."

*"The American Arts College (A Limited Survey), "by Frederick J. Kelly, Ph.D., Dean of Administration, University of Minnesota, with Aid of a Subvention from the Commonwealth Fund of New York. The book was published in 1925 and was a report of a study of Curricula, Extra Curricula and Teaching Methods in the Arts Colleges, sponsored by the Committee on Administrative Units which is a subdivision of the Educational Research Committee of the Commonwealth Fund of New York.

To the above statement of aims others were added, as: development of character, power, appreciation, a sense of values and social consciousness, enrichment of life, etc. Hadley of Yale is quoted as saying, "A good college education should teach a man those things which he will not need to use in after life by methods that he will need to use. . . . What are the habits and powers most needed by the citizens of a free country like the United States? . . . self-government . . . public spirit . . . constructive thought."

Further pertinent random notes taken from Dean Kelly's book are included below:

The test is not how much does the student know, but how does he modify his conduct because of what he knows. He should develop such intellectual traits as will assure a studious attack upon life's problems and such moral strength as will assure living among civic and other social and leisure problems in conformity with life's highest demands. Out of thirty-seven prominent alumni, only two rated the information acquired at college as important as the habits of study acquired and the ideals of character established.

Methods of teaching the subjects for the three different aims listed above should be different and the training of the teachers, different. If the aim is not to impart information, then the teaching should not be such as to enhance this aim.

The function of a college, in addition to preserving health is, a tool below, a vocation above, and culture in between. The keynote of teaching the tool subject is to memorize and develop skills. The keynote of culture is thinking, interest, and participation. The keynote of the vocational is systematic technical information and application. Teachers of these three different things require different qualifications and training. The tool subject teacher needs to secure a lasting memory. Broad culture except for citizenship duties is not needed. The teacher of the cultural subjects needs a broad culture so he can interpret the problems of life. He needs a thorough knowledge of students so he can adapt the material to their use. The teacher who gives more attention to subject matter than to students can not succeed. The vocational teacher needs a thorough knowledge of the field.

In evaluating results the tests are:

Tool Subject: Can he use it in his further study?
Cultural: Is he living it?
Vocational: Does he know it and can he apply it?

A basis for selecting materials is:

Tool Subject: What will the student use?
Cultural: What will secure thinking resulting in a social viewpoint, broad perspective, exercise of initiative, trustworthy mental habits, high resolves effecting the submergence of self in the social good
Vocational: What does the vocation call for?

High school students go to college without having been properly trained to study, and wanting to. They have been given a lot of information which they have forgotten. Send us students able to study, and wanting to study, say the college teachers, and we care not what they studied while in high school. Here the writer adds his own conclusion, deduced from the foregoing discussion, that if students know how to study, what to study and if they want to study, the cultural part of their college course is finished before they begin it. The length of the cultural interval between the tool and vocational studies will depend somewhat upon the economic situation.

Our present procedure operates against the brightest student. The exceptional student must work up to his maximum if leaders are to be developed. Certainly, every student should extend himself, and none should get the loafing habit.

College teaching should be varied according to aim. . . . Lectures usually are not good; . . . question and answer method is good if questions are thought provoking and not quizzes to determine if assignments have been read. . . . First decide what your subject is supposed to do for a student, and then adopt a method to achieve this end. It is granted that mastery of information is not the aim of the cultural course, but that initiative, habits of study, etc., are the aim, then it goes without argument that certain methods of teaching long practiced are not acceptable.

Alumni criticisms were: too much lecture, too little student participation, teachers interested in subjects rather than in students, miss students' viewpoint, poor adaptation of work to students' abilities, emphasize facts and memory rather than reasoning, thinking, initiative; teachers too academic, pedantic, dogmatic, impractical, and make too few applications to real life situations. Other questions brought out the fact that inspirational teachers ranked highest, habits of study gained, next, and information ranked last. Inspiring personality ranked far above profound scholarship.

Our whole scheme of marks, credits, promotions and graduations throughout the entire sytem has the tendency of impressing upon the student the importance of doing what he is told, rather than in seeking to gain mastery either of himself or the field of learning. When thrown upon his own resources, he must go through a period of failure before he learns how to direct himself and to overcome his tendencies to waste time.

Many of the committee's conclusions concerning the arts college may be applied to the engineering college. That the method should be such as will accomplish the fundamental objective of the course should have attention. The major objective of the technical course may be to impart technical information, but there are many other aims which must be included.

It even seems, if we follow the foregoing definition of culture closely, that the engineering college must teach culture. At least there are certain qualities, perhaps we should say, habits of mind, which will be developed nowhere else. The student comes to us

from the high school, or possibly from the arts college, not knowing how to study effectively, lacking in self mastery, not knowing how to think systematically nor to concentrate. He does not know how to ferret out unknown facts nor how to marshall the known facts and reach a logical conclusion from them. Systematic memorizing he does not understand. We must teach him these things. We must teach him how to conserve time. We must teach him how to approach a problem, how to analyse it and how to organize a piece of work. We must strive to develop initiative, resourcefulness and character. Each student should be trained to extend himself and none should leave college with piddling or loafing habits. Some hints as to methods of handling men and getting along with one's fellows might prove valuable. It is a big order, but these things are just as fundamental as technical information. We are trying not merely to make an engineer, but to develop an individual to his highest possibilities. It is foolish to think that one orientation lecture per week throughout the Freshman year can accomplish all of these things. They must be added to the aim of every course taught and the method so modified as to accomplish them at least in part.

How to accomplish these things is not an easy problem. Let us take for example, a course in elementary surveying. First we list the objectives. The primary objective is to impart knowledge of the practice of surveying. To this we may add, as secondary objectives, applied mathematics, accuracy of measurements, the meaning of significant figures, systematic computations, analysis of a problem, organization of work, systematic memorizing, logical thinking, clarity of expression and the value of honesty.

In planning a course of study it is never advisable to begin at page one in the text book and go straight through until the end of the semester stops the procedure. A survey of the field of surveying should be made and a list prepared including all of those things which should be known by anyone conversant with the subject. Weight the several items in the list in the order of their importance. Then select, in the order of their weights, as many of the items as can be covered in the time allotted to the course.

With this list in hand, select one of the aforementioned secondary objectives and combine it with some topic in the list. Continue until each secondary objective has been combined with some topic in the course. It will be found that each of the aforementioned secondary objectives will fit logically and easily into some topic of a course in elementary surveying. The only difficult part of the procedure is the selection of the topics to be included when, as is often the case, the time allotted seems insufficient adequately to cover the course.

Instructors appreciate being allowed to determine the content of their own courses, set their own standards and follow their own methods. This may be a dangerous practice. When it is done, there may be a great disparity in the standards set by the different instructors. When an instructor advises all but the best students against trying to carry two of his courses simultaneously, he admits that his standards are too high. Some adjustment should be made, either lower standards or increase the credit carried by the courses. The instructor is too close to the subject to see it clearly. Some particular aspect of it may intrigue him, particularly if it is something that he has developed himself. Presenting this particular aspect of the subject from year to year makes it seem of increasing importance to him despite the fact that it may be waning in importance in the engineering field.

Periodically there should be a check on all courses to equalize standards, to see that instructors are not riding too many hobbies, that all subject matter is vital, and that the methods used are accomplishing the objectives of the courses. This could be done by a committee of faculty members with perhaps an engineer or two from outside the teaching profession.

If a committee coördinated all courses, set standards and wrote the final examination questions, instructors would be on a competitive basis. Teaching methods would immediately show improvement. Such a procedure might not be advisable. However, the writer believes that a committee should exist and review all courses periodically.

A schedule of work should be presented to the students at the first class meeting. This schedule should include all assignments of reading matter, problems, and field work. It should be complete and held to rigidly. Such a schedule will permit the inclusion of a little more subject matter than can otherwise be covered. If the student knows that this schedule represents the entire course, he will not object to its length, nor will he offer objections to covering that amount of work, if, perchance, unexpected holidays or other interruptions to class or field work occur. He likes to know the scope of the course, and indeed, some students like to study ahead, on occasion. He should be encouraged to plan his work. He can not do this if there is uncertainty as to the amount and scope of the work to be done. He should be encouraged to extend himself to his limit. He will be more likely to do this if a schedule is set than if the schedule is made dependent upon the progress of the class. Scheduling the work and holding rigidly to the schedule will eliminate the bulking of assignments at the end of the semester, or the omission of the later assignments from the course.

Furthermore, a schedule of a semester's work showing all as-

signments, handed to the student at the beginning of the semester, relieves the instructor of making daily assignments, which not only takes up recitation time and tends to employ the instructor's attention when it should be on the lecture at hand, but also interferes with the instructor's proper approach to his lecture. The recitation or lecture should begin impressively. Hesitations at the beginning of a period, thumbing over notes, making assignments, etc., have the wrong psychological effect. The professor should get the attention of each and every student immediately he steps into the room and hold it during the hour, carrying their minds along step by step according to a preconceived plan, modifying the plan as the lesson develops and the need of the students becomes apparent. Lecturing from notes can never have quite the same vitality as a lecture without notes. It does not allow the instructor the opportunity of watching the response of the class.

Watching the response of the class has caused the writer to forbid the taking of notes, as a general practice, in his classes. Taking notes from a book is a valuable exercise. The ability to take notes from a lecture is valuable. Special exercises in the taking of notes should be given on occasion. However, thinking over the ideas presented in a lecture, examining the implications involved, questioning the instructor and getting a thorough understanding of the material presented is more valuable to the student than writing down some conclusion the instructor may make, to be memorized before examination day. Most instructors lecture so rapidly that there is not time for the students to accomplish both of these things. At the conclusion of some explanation or demonstration before a class the writer has noted the gleam of comprehension in the eyes of the students. If note taking is required and he continues immediately with other demonstrations, he will get this indication of comprehension from an occasional student only. The others will be too busy writing notes to have any but the vaguest idea of what he is talking about. Unless the aim of the course is the imparting of information only, the instructor must give adequate time for the taking of notes, if he requires notes to be taken. If the aim is merely to impart information, why not mimeograph the information and present, or sell it to the students? The writer once heard of an economics class in which the instructor read an outline from notes, making practically no comments, the students' entire time being taken up with the copying of the outline which the instructor read. How much better it would have been to have mimeographed the outline for the students and spent the time in discussing some of the implications involved. At least the students would have been spared this additional encouragement towards poor handwriting.

Someone has mentioned a sense of humor as a good qualification for an instructor. Perhaps it is if he keeps it in the background. It is easy enough to get the members of a class into a hilarious mood, but much time is wasted in getting them out of it.

The writer believes in thought-provoking questions introduced in a general way. To ask a question of one student just to see if he has studied the lesson is a waste of time for the other students in the class. Questions have been asked which started a buzz in the class room, each student arguing with his neighbor. Let them argue for awhile, then ask a few more questions which will settle the argument. The writer knows one instructor who is able to come back with a leading question to every question asked of him, so that eventually the student answers his own question. This is teaching of a high order.

In the matter of a schedule, it may be said in passing, that field work, indeed all class work, should be carefully planned and the plan held to. There is nothing quite so disheartening to the student as to have a certain set of instructions given him concerning some field work, and then to have the instructor make a change after the work is started. There is nothing that gives the student quite so poor an impression of the instructor as indecision. To plan the field work properly requires considerable time since the different types of work require different numbers of men in the parties. Much care must be exercised in order that each student be kept busy. The problem of creating interest does not seem to enter. Students are naturally anxious to try their hand at a practical course like surveying and will keep busy and work overtime willingly and anxiously if the work is only planned so that each student has something to do every minute, and knows what he is to do. If one student is unemployed, he will naturally get to playing and the whole job will begin to slow up and interest will wane. It may be worth something to send three students out with a transit, one to run the transit, the other two to hold points, as is done in practice, but it is probably better, after a short period of this, to line up a number of transits in a closed traverse, for instance, five transits for six students, and let them rotate, going from transit to transit, and spending the entire afternoon measuring angles. It will take much time so to plan the field work as to have no waste of the student's time, and to make each student extend himself to the limit, but it should be done. No absences from field periods can be tolerated. This is necessary for a smooth working field plan and it is good training. Good notes must be insisted upon. This too, has an educative value beyond its mere value in surveying.

Let us take up in class the chapter on the transit, its use and

adjustment. We begin with the problem of measuring a horizontal angle between two lines emanating from a certain point. We go back into history to the use of a protractor and two strings. The need for a convenient and accurate instrument becomes apparent. With the aid of the class, such an instrument is developed, step by step. The sighting vane is substituted for the strings, and a telescope for the sighting vane. Next comes the astronomer's twelve-foot circle, followed in order by the vernier, the two plates, the tripod, the shifting head, and the plumb bob. Other uses for the instrument are proposed and we develop the telescope bubble and the vertical circle. This method of approach creates interest, gives a more thorough understanding of the instrument, aids memory, and is an exercise in logical thinking.

To adjust the transit, we list all of the uses and go through each, under varying conditions, with the instrument before the class. Conditions which must be satisfied, if good work is done with the instrument, become apparent, and methods of making the adjustments are suggested by the actual use which required the adjustment. Students learn that one thing follows another in logical sequence. They must learn that, in thinking a thing through, one thing must follow another systematically. To sit and wait for an idea to jump into their minds is not thinking. It is merely trying to think.

The same is true of memory. There must be a system. It is assumed that a transit is brought to the student for examination. He will never remember to examine every part unless he uses some system. If he is taught to begin at the bottom, and go up, first examining the shoes, then the tripod, the plumb bob chain, the leveling screws, etc., he will perhaps do a good job and at the same time get a lesson in aiding memory by the systematic approach.

Surveying offers an opportunity to teach the organization of a job. Men can take turns as chief of party and get some experience in planning a job and working a plan. Certain fundamentals of job organization can well be emphasized.

The development of character can be encouraged by showing the need of honesty as a qualification of a surveyor. The surveyor needs to be honest with himself, and this is a good point. The matter of cheating on examinations should not be overlooked. An instructor who has had practical experience in hiring men and directing the work of subordinates, can make a good case against the cheater. He can show how promotion and pay comes with competency, dependability and loyalty. He can show how the man, whose success depends upon the performance of his subordinates, can not afford to have a foreman working for him who will pad the payroll, or a superintendent who will purchase his materials from

the dealer who will give him a rakeoff. He can prove that the employer of men would lack confidence in a man who cheated in college and would not want to hire him and could never promote him to a responsible position. The very act of cheating establishes some or all of the following characteristics; incompetency, laziness, lack of confidence in one's self, and dishonesty. These facts should be pointed out to the student. He may think that cheating indicates only that he is clever.

Creating interest presents no problem in particular in the technical school. However, there are varying degrees of interest. The practice problem never seems to have quite the same vitality as an actual practical problem. Actual problems are hard to adapt to a field schedule. The general public never seems to understand why an already crowded schedule can not be interrupted for a couple of days while students cut brush in an attempt to find some lost public land corner.

Occasionally, however, a good problem can be assigned. Two triangulation stations of the U. S. Coast and Geodetic Survey were found, well marked and undisturbed, within a radius of twenty-five miles of the University of Arizona. Using these two stations to form a base, the Mines and Engineering Building was tied into the U. S. C. & G. S.'s triangulation net and its geographic position computed. Ten triangulation points were located in and about Tucson. A check base was measured and the distance reduced up from sea level. A check of one over fourteen thousand was obtained. Repeating instruments were used and the observations made at night. Coleman gasoline lanterns were used for signals.

The students went out on Friday or Saturday evening and remained until about midnight. To climb two thousand feet in a distance of two miles up a pathless mountain, observe until midnight, and then carry a heavy theodolite down in the dark is no child's play, but the students liked it. How much more the students learned than they would have in an ordinary practice problem, the writer does not know. It is certain that they took a very live interest in the work and obtained a great deal of satisfaction from its accomplishment.

Grades are an abominable nuisance. Let me restate from Dean Kelly's book. Our whole scheme of marks, credits, promotions and graduations throughout the entire system has the tendency of impressing upon the student the importance of doing what he is told, rather than in seeking to gain mastery either of himself or of the field of learning. When thrown upon his own resources, he must go through a period of failure before he learns how to direct himself and to overcome his tendencies to waste time.

This criticism of the arts college may be applied to the engineering college. To pass a course, a student must study the subject. To be sure always of making a high grade he must also study the professor. What a waste of time!

This is not intended as a criticism of the professor. He must necessarily "see according to his own light," but it tends to make a "yes man" out of the student. This tendency should be avoided.

Much of the instructor's time is spent in the marking of papers which may have no other purpose than the evaluation of the quality of the student's work. Much time is spent in keeping records which might more profitably be used on other work. If grades were dispensed with, it is conceivable the teaching staff might find the time to permit students to progress through the entire four year course at a speed determined by their individual abilities. Such a plan would cause each student to extend himself to his limit. Ranking would depend upon the time spent in covering the course.

The writer listed a number of secondary objectives to be added to a course in elementary surveying. However, he still follows precedent and gives a grade to each student who can demonstrate that he has learned the art of surveying. If the grades given more closely reflected ability along the lines of the secondary objectives, they would perhaps give a better indication of the students chance of success in the profession.

Students should be taught the follow-up method of study. Ten minutes of study after the lecture may be as valuable as an hour's preparation. The fact that a student learns by doing should not be lost sight of. Just how much help a student should be given is a moot point.

With no help at all, only the genius could ever make a start. We begin to give help when we write the textbook. We continue when we add the instructor. The instructor should realize that he is paid to supplement the textbook. To make the assignments and mark the papers is not enough. The writer inclines to the belief that the course should be made harder by the addition of subject matter and easier by the improvement of methods.

The help that is given should have as an objective aiding the student to help himself. The sooner the student arrives at the point where he no longer needs help, the more successful has been the instructor's method. Another objective is to avoid the waste of time. It is educative to the student to work out a hard problem for himself; but it is a clear waste of time for students to work hours on problems which they have no hope of solving, as is often the case when the instructor fails to give the proper pre-study instructions. A certain class failed to complete the last chapters of

a text in analytic geometry. This same class wasted hours trying, unsuccessfully, to solve a calculus problem which was dependent for its solution upon a knowledge of analytic geometry contained in that part of the text which they had not covered. An alert instructor would have noted in his assignment the necessity for a review of a certain chapter in analytic geometry. The problem would still have been sufficiently hard for mental development.

There is a student attitude, rather common, which should be corrected. To illustrate it, suppose a problem, new to both instructor and students, needs solution. The students fail, the instructor succeeds, not altogether because of his better knowledge of the proper approach, but because he knows he must. Too many students are satisfied when they have made an attempt. Too much work is done with the hope that it is good enough. Few students understand how thin is the line that separates success and failure. We must impress this upon their minds and instill into them a determination not to stop short of success.

Law colleges find that students with two years of arts preparation make better grades than those with four. Bad study habits indulged in for four years are hard to break. We must be sure that our students are forming the proper habits of study. It is not enough to know that a student has mastered a lesson. We must know how he did it. We must be sure that he is acquiring the habit of mind that will assure successful accomplishment. He should acquire the attitude of "I can if I must, and I must." Four years of the attitude "I will give this a try and hope it satisfies the instructor; it is only a practice problem anyway; perhaps I will never need it," may not be any too good for the student. We must so vitalize our problems and perfect our methods as to cause students to extend themselves to the limit of their abilities. That we are not entirely succeeding in this is evidenced by the quality of work done by graduate students who remain for another year of work immediately following graduation.

English composition has an engineering approach. We first list what can be said, then decide what will be said, say it, and then check to see if we have said exactly that and nothing else. The problem of teaching English composition is ninety per cent solved when an instructor is employed who can make engineering students want to write.

The writer's experience in the practical field has made him something of a crank in the matter of dependability. He is appalled at the lack of a feeling of responsibility in college students generally. Engineering students are not as bad as some others but many lack this quality entirely. A recent newspaper note stated that filling station operators and attendants had done more

to promote common courtesy than all the colleges in the land. Is there any reason why we should neglect to teach these things? The college should lead, not follow.

A man coming into a college from commercial work will get the impression that the college is following, not leading. Full professors often do certain routine work that might be done just as well by personnel costing fifty cents per hour. No corporation would tolerate such an arrangement. Conditions of lighting and heating, which would not be tolerated in an up-to-date factory, are often considered adequate for student work. Up-to-date factories make job studies to increase the output of the workers. Students are allowed to muddle through in any way that suits their fancy.

It may be said in all fairness to the college as it is to-day that, in spite of all the apparent faults, good results are being obtained. The writer, in his last tour of the college, had reached the age when his mental habits were pretty well fixed. He, consequently, had a good vantage point from which to view the growth and development of students throughout their four years in an engineering college. That growth and development was remarkable. It increased his faith in our educational system and in the engineering college. Perhaps we are not so bad after all.

It has been said that it is generally educative for a student to have a variety of teachers, both good and bad, but who wants to be rated as the bad teacher? He is probably one of the educational wastes and does not earn his money. To avoid this pitfall, the instructor should realize that the world does change, that he must be eternally vigilant to keep his subject matter up-to-date, his objective vital and his method such as will accomplish his objective.

THE FUNCTIONS OF ENGINEERING

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Engineers may be classified, according to the titles they bear, in a number of different ways. They may be grouped by traditional *major fields* (civil, mechanical, electrical, etc.); by the *structures* or *products* they work on (bridge, cement, telephone, etc.); by the *special technology* they employ (acoustical, ceramic, combustion, etc.); by the *functions* they perform at the various stages of an engineering enterprise (research, design, construction, sales, etc.); by the *capacity* in which they serve (consulting, practicing, teaching, etc.); by *rank* (assistant, associate, chief, etc.); by *geographical location* (county, district, division, etc.); and by *professional status* (licensed, registered, retired, etc.).*

To educators and others concerned with the vocational guidance of engineering students, perhaps the most revealing and interesting of these types of classification at the present time is that by *function.* Functional titles are descriptive of the duties, services, or activities performed by the engineer as the major part of his daily work. Such a title should answer the question: "What does this engineer *do?*" If the domain of engineering is examined from the point of view of the activities of its practitioners, it is found that there is a long list of these functions which the world expects the engineer to perform with professional skill.

During the course of any engineering project, from the time when a particular human need is recognized until the time when that need is satisfied through organized engineering effort and the resulting product is put into use, a number of functions must be performed. The word "function" is here used in its common meaning as "any special kind of action, activity, office, or service properly belonging to a person or thing." These functions are in general the same regardless of the product or structure that finally results from the project. That is to say, a good bridge designer must not only know something about bridges, but he must also know the principles of design; a good sales engineer must know his product, and must also know how to sell; the manager of a manufacturing plant will be confronted by many of the same

* See "The Structure of the Engineering Profession," by Theodore J. Hoover, JOURNAL OF ENGINEERING EDUCATION, January, 1935, pp. 356–372.

executive problems as those encountered by the manager of a mine or the manager of a construction company.

Until modern times, only two functions among all those required in an industrial undertaking were recognized as the special province of the engineer—design, and the supervision of construction. During the past century, however, he has been called upon to take over an increasing number of functions, until to-day almost a hundred different functional designations may be discovered from the titles which engineers use to describe themselves in the yearbooks of their professional societies. This rapid widening of the accepted province of the engineer, not only in special technical branches but also in functions performed, is at last coming to be clearly recognized by engineering educators; however, there are still many practicing engineers who are unaware of its importance, while the general public cannot be expected to know that there is a difference in kind between the special technology of engineering and its functional application.

The enlargement of the functional range of the engineer has not proceeded without opposition. Not so long ago, it was felt by many that an engineer should stick to his transit and his drawing-board, and should leave all the economic and financial aspects of the undertaking to hard-headed business men and glib-tongued company promoters unhampered by the "impractical" consequences of a training in scientific thinking. The acumen and high repute of those engineers who ventured in earlier days to take a real part in the direction of the economic as well as the technical phases of a business enterprise soon led, however, to such markedly successful organizations that to-day the investing public is demanding the replacement of the "Get-Rich-Quick Wallingford" type of promoter by a man with the engineering type of mind, trained in the scientific determination of facts and their application according to objective principles. It was discovered that the fact-method of engineering was successfully appplicable also to problems of personnel management, sale of technical appliances and services, estimation of costs, statistical surveys, and studies of industrial efficiency. One by one, functions formerly handled by the banker, the business man, the inventor in the garret, the salesman, the promoter, and even the lawyer, have been passed along to men holding engineering degrees.

The engineer in some cases has shouldered these responsibilities with reluctance, for it has meant forsaking the realm where highly accurate physical measurements and proved formulas can be applied to inanimate materials, and pioneering in the larger realms where the vagaries of human nature and the unpredictables of social and political programs must be dealt with. But to-day, most

engineering schools recognize the importance of developing men who will be capable of exercising these new functions of the profession with trained competence, and courses in engineering economy, social science, law, finance, business management, government, transportation theory and other commercial aspects of knowledge usually—and rightly—occupy as large a share of the curriculum as the purely technological courses. An engineering education has come to be recognized as an excellent liberal and cultural training for life in an age of scientific progress, and especially as a preparation for careers in business and industrial administration, and the performance of executive functions in many fields.

Value of Functional Classification

What may be the special value of giving consideration to the functional grouping of engineers in contrast to the other possible types of classification? Educators may find of special interest the following:

1. A clear recognition of a difference in kind between the functions performed by engineers and the special technological fields in which they carry on these functional activities might lead to less confusion in the organization of the various departments of engineering colleges. The classification by function runs at right angles, so to speak, to the classification by field of interest. It is plain, for example, that a Division of Engineering Administration represents a function, and is not a separate field of engineering on a par with the fields represented by Civil, Mechanical, Electrical, Mining, and Chemical Engineering Departments; the administrative function may be exercised in any of these traditional fields of interest, and its principles are in general the same no matter in which major field the function is exercised. It is therefore felt by many to be illogical to consider that such a division as Administration Engineering should be organized under the Civil Department, say, rather than under the Mechanical Department or any of the others. An alternative is to set up functional divisions within every major field, although objections might arise if each major department, such as Civil Engineering, were to be made up of divisions such as Civil Engineering Administration, Civil Engineering Research, Civil Engineering Construction, Civil Engineering Finance, and the like. No one would boldly suggest at this time that the old traditional classification into fields of interest—civil, electrical, mechanical, mining, and chemical—should be altogether abandoned by the engineering schools and replaced by departments of Engineering Administration, Organization, Research, Design, Construction, Sales, and the rest of the main functions. Yet there is good reason to believe that the trend of engi-

neering education is swinging in the direction of clarifying the functional status of the engineer as contrasted with the more or less accidental designations which have traditionally grown up. The administrative difficulties of putting such ideas into effect are discussed in a recent article * describing the present status of the engineering school set-up at Columbia University. The authors significantly state: "We educators welcome this survey of industries [by the American Engineering Council], but what we need most is a classification of the engineer's functions. Possibly every thinking teacher has made such a functional analysis for his own guidance but his available data are limited. Such an analysis would be of equal value to engineering societies." The present article is an attempt to discover what these functions really are, to determine the relative number of men in each functional group, and to define tentatively the activities and special characteristics of each group.

2. Present efforts at the vocational guidance of engineering students are based upon studies of differences in individual interests and personality traits. It seems more likely that the educator will be able to find the greatest, and most useful, differences among individuals if he considers the functions to be performed than if he attempts to discover traits that would lead a man to be more successful in one or another technological branch of engineering. The personal qualities that would make a successful inventor, designer, executive, salesman, organizer, planner, or research worker are more easily discoverable, and may be discovered earlier, than any special interest that would lead a man to engage in fields of effort connected with automobiles, power lines, bridges, dams, telephones, mines, machine tools, or the like. Most engineers will admit that they entered their particular field of work more or less accidentally; they became railroad engineers or radio engineers or sanitary engineers because of early employment opportunities, or because that branch of engineering was thought to be "the coming thing," or because of the impression made upon them by a particular individual whose enthusiasm for his branch of work was communicated to them. But it is less likely to be a matter of chance that a man in any field is an executive, or a research worker, or a salesman; no matter what that field is, he is generally to be found exercising the function that most suits his personality. The "square peg in the square hole" is found there primarily, it is believed, because he fits his job functionally. Competence to deal with problems in one or another branch of special technology may be acquired if

* "A New Curriculum in Mechanical Engineering," by F. L. Eidmann, W. A. Shoudy, and T. Baumeister, Jr., *Mechanical Engineering*, August, 1935, pp. 483–485.

interest steers one in that direction; but a man who is a "born salesman" will be decidedly out of place in the research laboratory, just as the "born manager" will find it irksome to be condemned always to work out the details of structural design. In short, with present methods of vocational placement it is possible to discover individual differences in functional traits more easily, and earlier, than to discover differences that might make a man successful in one or another technological branch of engineering. An effort will be made in the lists following to suggest what some of these traits might be.

A Study of Functional Titles

Neither of these two benefits of the functional viewpoint can be realized, of course, until there is a clear understanding of the answer to the question: "Just what are the functions of engineering?" There have been only a few scattered attempts to answer this question, and to define the functions that the engineering profession is called upon to exercise to-day. The purpose of this paper is to attempt to discover and define tentatively all the recognized functions of engineering, in an effort to establish a basis for future discussion of these terms as used by practicing engineers.

Ninety-seven different functional adjectives were discovered among all the thousands of titles appearing after the names of all the men listed in the various 1931 directories of members of the five major engineering societies (American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, and American Institute of Chemical Engineers). Each of these functional terms found modifying the word "engineer" is listed below, and an attempt is made to define its meaning.

Only tentative definitions are possible at this time. It would seem that the burden of describing these titles should fall upon the men who use them and who should therefore be prepared to justify their selection of terms. In default of such volunteered definitions, it is possible only to formulate brief descriptions of these functions on the basis of a general understanding of engineering terms and a study of the literature of the profession. A fairly wide acquaintance with many phases of engineering still does not permit one to guess the meanings of some of these titles. The list is offered mainly as a beginning for discussion; and it is hopefully requested that any criticisms and suggestions that are aroused by a reading of these proposed definitions will be sent to the author, so that he may make revisions based upon a wide range of opinions on suitable functional nomenclature.

A number of these terms appear to be used without any clear general understanding of their meanings. It would seem that any title which conveys only a hazy suggestion to the engineer, and no meaning at all to the layman, defeats the primary purpose of a title in that it is not *descriptive* of the work performed by that group. Moreover, several terms may be found which, although they appear to make useful distinctions between groups, are actually synonymous. On the other hand, some overworked words are used in three or four different meanings. A "development" engineer, for example, denotes to electrical engineers one who takes the results of research and adapts and applies them for industrial manufacture or use in a particular process; while to the mining man, a development engineer is one connected with the exploration of a mineral deposit by drilling or driving openings into the vein. Wherever rival meanings for a functional title are revealed, it would seem wise for engineers to discover and use descriptive and separate words for each conflicting meaning. In the above instance, the electrical engineer might preferably call himself an "application" engineer, relinquishing to the mining engineer the older and more entrenched title.

The figure in brackets after each title to be defined shows the number of times that this particular designation was found in the study of all engineering titles. This figure is only a relative guide to the frequency of use of the term, however, for it does not include the number of times that the functional word was used in combination titles with adjectives indicating other branches of engineering. At best, the number of men bearing a title is a poor guide to its importance as a proper function of the profession, so frequently are terms misapplied and misunderstood under the present state of engineering nomenclature.

An asterisk has been placed before those titles which are judged by the author to designate the proper and important functions of engineering at the present time.

The special qualities that are considered to be requisite for success in certain of the functional branches defined, and which are judged to differentiate their possessors from men in other functions of engineering, are given after many of the definitions. More extensive and scientifically determined lists of these qualities, could they be obtained, would serve as highly useful "job specifications" for the guidance of those faced with the problem of selecting a field of endeavor. The qualities named are those which are assumed to differentiate among engineers rather than to be common to all engineers; it is taken for granted that success will also depend upon individual intelligence, education, experience, ambition, and personal efficiency.

Where two or more synonymous word-forms have been found (e.g., "accounting" engineer and "accountant" engineer), the preferred form is given first, with the alternative in brackets.

Definitions of Functions

***Accounting (Accountant) Engineer** (4).—One skilled in the recording, preserving, and verifying of facts concerning the acquisition, production, conservation, and transfer of values. A cost-accounting engineer would be charged with the duty of obtaining unit costs for use in promoting economy in operations and in estimating future costs. *Special characteristics:* Knowledge of bookkeeping methods; ability to analyze processes of construction and production, to interpret financial records and statements, and to present the results in form suited to utilization by executives; accurate mind and feeling for meanings of figures.

Administration Engineer (1).—Same as "executive engineer." Only one found in the study (civil).

Advertising Engineer (1).—Only one found (mechanical); not a very valuable designation.

Analytical Engineer (1).—One presumably concerned with the analysis of engineering problems; only one found (civil).

***Application Engineer** (5).—This type of engineer presumably takes a new invention or process and applies it to a particular industrial purpose. See "development engineer," meaning 2.

Appraisal Engineer (14).—A valuation engineer connected with a firm of appraisers. See "valuation engineer."

Betterment Engineer (1).—Probably one concerned with improvement of plant or property to increase its earning power; only one found (mechanical).

Calculating Engineer (3).—One who makes engineering computations. It is doubtful if this activity should be classified as a professional function, although a number of employees of the U. S. C. & G. S. bear the official title of "computer."

Commercial Development Engineer (1).—Only one found (mechanical): see "commercial engineer."

***Commercial Engineer** (50).—This type of engineer is more concerned with the business aspects of engineering than with the technological phases. He is a business man with engineering training, and is concerned primarily with economics rather than with the physical sciences. The title is frequently misused, and is something of a misnomer, since almost all types of engineer must consider commercial aspects. *Special characteristics:* Business knowledge and ability; appreciation of economic and commercial aspects of engineering enterprises.

Commercial Sales Engineer (1).—Only one found (mechanical); see "sales engineer."

Commercial Survey Engineer (1).—Only one found (electrical); see "survey engineer."

Conservation Engineer (1).—One concerned with the reduction of wastes in natural resources, the utilization of by-products, or the substi-

tution of one material for another more expensive or scarce material. Only one found (mechanical).

***Construction Engineer** (265).—One who supervises the building, erection, or fabrication of engineering structures. This is one of the most ancient functions of engineering, and is among the top three or four in point of number of men enlisted. *Special characteristics:* Technical skill and knowledge of current building practices; knowledge of behavior of materials; organizing and executive ability; planning; and coöperative skill and tact in dealing with those who have designed and those who will use the structure.

Contracting Engineer (86).—A construction engineer who carries also the responsibility of entrepreneur. This distinction is not especially useful from the functional point of view, although a large number of men bear this title. See "construction engineer."

Control Engineer (15).—This term appears at first sight to be functional, indicating executive supervision of all operations. It should rather be assigned to the zone-of-interest classification. Almost all of the men who use it are electrical engineers, and the term should be defined as one who designs or invents devices for the control and efficient utilization of electricity.

Cost-control Engineer (1).—Only one found (electrical); see "accounting engineer" and "cost engineer."

***Cost Engineer** (20).—An accounting engineer especially concerned with economy and efficiency of industrial operations through utilization of accurate cost figures. See "accounting engineer."

Cost-reduction Engineer (2).—Probably a type of "efficiency engineer"; only two found in the study (both mechanical).

Data Engineer (2).—Probably a research engineer who collects, analyzes, and submits results of study; only two found in the study (both electrical). See "research engineer."

Demonstration Engineer (1).—One who gives practical demonstrations of the performance of a machine or commodity; a partner of the sales engineer. Only one found (civil).

***Designing (Design) Engineer** (423).—One who plans and delineates for the guidance of others a projected piece of engineering construction, usually based on specifications laid down by others. The designer must be guided by his experience of "good practice" for various types of structures, and by an understanding of the function and purpose of each structure. His education and skill assist his imagination to conceive a finished structure and to state, by drawings and detailed specifications, all required dimensions and materials. Designing engineering is one of the very largest of the functions of engineering, and has been from earliest times. *Special characteristics:* Ability to visualize completed structure or project in action; thorough knowledge of materials, stresses, construction methods. Most of the designing engineer's work will be done in the office, although some field trips may be necessary.

***Development (Developmental) Engineer** (169).—(1) A mining engineer who specializes in the exploration of the extent and value of a mineral deposit by drilling or driving openings into the rock. (2) An

engineer who applies inventions or new processes to industrial operations. The development engineer, in this sense, is one who starts with an original idea and by means of experimental models, tests, and calculations evolves step by step a practical apparatus suitable for use. See "application engineer." (3) A civil engineer who supervises the improvement or development of a land project.

Directing Engineer (2).—Probably synonymous with "supervising engineer"; only two found in the study (both civil).

***Distribution Engineer** (63).—(1) This type of engineer performs the physical process of conveying purchased articles to the consumer in an efficient manner; closely allied to sales engineering, and completing the series of functions between the inception of a project and the utilization of its engineering product. The term at present is vague and is primarily synonymous with transportation; the engineer seldom has any say regarding the proper distribution of profits or goods among various classes of consumers. (2) A sales engineer concerned with systems of marketing goods through wholesalers, retailers, etc. (3) An engineer concerned with the delivery of electrical power or gas to various users.

***Efficiency Engineer** (23).—The duty of the efficiency engineer is to observe, study, and make recommendations upon any of an organization's operations which might be performed more quickly, easily, cheaply, or effectively, both in use of equipment or in better functioning of the human units. Efficiency engineering is the application of the engineering method to problems of economical management, and the efficiency engineer plans for economy and sets up standards of performance based on research. Although efficiency engineering in its early days incurred some disrepute through the ill-timed promotion of its use by some of its adherents, the term is highly descriptive of an important engineering function; and it would seem that the time has passed when engineers need be shamefaced about using it or need resort to such unrevealing euphemisms as "industrial engineer." *Special characteristics:* A thorough knowledge of the literature of efficiency engineering; sound engineering training; skill in applied psychology; patience in instituting improved methods which require the changing of ingrained habits.

***Erection (Erecting) Engineer** (21).—(1) An engineer who supervises the assembling of a large machine. See "installation engineer." (2) A construction engineer engaged in assembling and uniting parts prefabricated at a distance from the site.

***Estimating (Estimate) Engineer** (24).—This type of engineer estimates the cost of a proposed structure or project on the basis of plans and specifications furnished him by his superior. These plans and specifications range from the most crude and tentative to the most precisely and accurately detailed. Such estimated costs serve as a basis for bidding by a contractor or as a basis for evaluating the absolute or relative economic promise of a proposed structure or project. The function of estimating is often considered to be part of the task of the designing engineer. *Special characteristics:* Knowledge of the principles of design, engineering economy, and processes of construction; familiarity with technique of estimating costs and with current prices of materials, unit wages, and output of labor.

Examining Engineer (3).—It is impossible to guess what sort of examining is done by this kind of engineer. Only three found in the study (one civil, one mechanical, one electrical).

***Executive Engineer** (31).—An executive engineer is a man with engineering training who is doing administrative work. His chief duty is to direct the work of others in an organization. The executive function must be exercised at every step in an engineering project, and the field offers growing opportunities for engineers with the proper qualifications. *Special characteristics:* Organizing ability; understanding of human nature; business instinct; forward vision; comprehension of aims and policies of the organization; decision; fairness; sound engineering background.

***Experimental Engineer** (32).—A research engineer who obtains useful data through special observations or tests. This type of engineer is closely allied with "development" of apparatus or processes through actual small-scale experiment. He is also practicing a special form of research engineering. Experiment differs from ordinary research in that it is not mere exploration or general inquiry, but is performed to confirm or disprove something doubtful, especially under conditions laid down by the experimenter. *Special characteristics:* Knowledge of experimental methods and techniques; understanding of logic; skill in devising apparatus for testing and experimenting; scientific accuracy in observing and recording phenomena.

Exploration Engineer (3).—A mining engineer who examines prospective mines; synonymous with "development engineer," definition (1).

***Finance Engineer** (None found).—Although no finance engineer was found in the study, the term is a good one and has been used in the title of a textbook. The application of engineering knowledge to financial problems is a growing function of the profession, especially in these days of large corporative and public engineering enterprises. Finance has been defined as "the science and practice of raising and expending public revenue; the management of money or conduct of monetary affairs, especially those involving large sums or having especial relation to investments." The engineer with a knowledge of finance is especially desirable during the planning of an engineering project after initial valuation has been made and before the organization of the personnel has begun. He should be consulted on problems such as: how the money required for operation shall be raised; what sum will be required for sound financial backing, without over-capitalization; what should be the expected rate of return on investment; and the like. *Special characteristics:* Thorough knowledge of the theory and practice of economics and financial procedure; realistic viewpoint regarding probable return on invested capital; ability to negotiate with bankers, brokers, capitalists, underwriters, promoters, and government officials, and to speak with them in their own language; social tact and affability; skill in applying the engineering method to intricate problems involving both monetary and human factors.

Fixed-capital Engineer (2).—Meaning unknown; this kind of engineer might be concerned with estimating amounts of capital necessary for plant construction and maintenance, or with costs of plant improvement, or with half a dozen other phases of engineering. Only two found in the study (both electrical).

Foreign Wire Relations Engineer (3).—A telephone or telegraph engineer who acts as a liaison officer between the local company and affiliated companies, domestic or foreign. This is a cumbersome and not especially revealing title to the layman.

Fundamental Plans Engineer (1).—Only one found (electrical); see "planning engineer."

Induction Coördination Engineer (2).—An electrical engineer who carries on negotiations to eliminate disturbances in the operation of electrical apparatus caused by induced currents from other apparatus. Only two found in the study.

Inductive Relations Engineer (1).—Same as "induction coördination engineer"; only one found (electrical).

Industrial Control Engineer (1).—See "control engineer"; only one found (electrical).

Industrial Economics Engineer (4).—One who specializes in the application of engineering economics to industry. His work might include research and collection of data on costs, prices, sales, etc.; valuation problems; financial planning; efficiency; and engineering surveys. See "industrial engineer."

Industrial Engineer (176).—A popular synonym used to evade the presumed stigma that has attached to the term "efficiency engineer." The word is not descriptive of any particular function, because the work of almost any engineer is "industrial" in every sense. The title should be replaced by more descriptive titles such as "efficiency engineer," "management engineer," "production engineer," or the like.

Industrial Management Engineer (2).—Same as "management engineer" and "efficiency engineer." Only two found (both mechanical).

Industrial Research Engineer (1).—Only one found (civil); see "research engineer."

Industrial Sales Engineer (2).—Only two found in the study (one civil, one mechanical); see "sales engineer." The adjective "industrial" is probably used here to indicate that the product sold is not a domestic appliance for retail sale.

Industrial Service Engineer (1).—Only one found (electrical); see "service engineer."

***Inspection (Inspecting, Inspector) Engineer** (15).—One who observes and reports upon the quality of engineering construction or fabrication, either at the time of construction or after the product has been completed. The inspection engineer is frequently assigned to follow the progress of a contract engineering job for his employer, and to see that specifications are fulfilled. *Special characteristics:* Alertness; knowledge of standards of materials and performance; knowledge of inspection codes and specifications; loyalty to employer.

Inspection Methods Engineer (1).—Only one found (electrical); a highly descriptive title composed of two functional words. Presumably this type of engineer specializes in devising and instituting improved processes of inspecting the quality of manufactured goods.

Installation (Installing) Engineer (15).—One who supervises the erection or installation of machines, apparatus, or equipment, to make sure that they are properly put into service. *Special characteristics:*

Thorough knowledge of construction and operation of particular equipment to be installed; executive ability; knowledge of performance standards and testing techniques.

Installation Service Engineer (1).—Only one found (electrical); see "installation engineer."

Installation Supervising Engineer (1).—Only one found (electrical); see "installation engineer."

***Insurance Engineer** (4).—An engineer who applies his knowledge of engineering to the insurance business. Certain companies specialize in the insurance of engineering plants, structures, and machines; engineers are also particularly useful in determining risk rates for fire, earthquake, and failure of materials. Protection devices also lie within the province of engineers. *Special characteristics:* Knowledge of economics and principles of valuation and insurance; sales ability; familiarity with design and construction.

***Invention Engineer** (None found).—Although "invention" is easily recognized as one of the prime functions of engineering, not a single man calling himself an "invention engineer" was encountered in the study. This is not surprising, however, when it is considered that some type of invention is required of engineers in almost every branch (the word "invention" is synonymous with the "ingenuity" from which the word "engineering" is derived); that few men devote all their time to invention; and that, moreover, there is usually some hesitancy in styling oneself "inventor." Invention may be defined as the act of devising or contriving, especially the contriving of that which has not before existed. It is related closely to research in that it is discovery as a result of purpose or forethought; hence, research must always precede invention. *Special characteristics:* High scientific curiosity; thorough knowledge of present state of technology in the particular field; ingenuity of the highest order; patience in experiment. As in the function of research, the inventor need not have physical ruggedness nor skill in making social contacts.

Investigation (Investigating) Engineer (3).—A seldom-used title synonymous with "research" engineer.

Layout Engineer (3).—(1) An efficiency engineer who designs or redesigns an industrial plant or office for most efficient movement of goods and expediting of processes, under standardized working conditions. Special characteristics same as for "efficiency engineer." (2) One who schedules for others the most economical plan for handling a job, providing for orderly and rapid progress. *Special characteristics:* Ability to visualize most of the contingencies in the realization of an engineering project, and to provide for meeting them on time; highly methodical habit of mind; knowledge of special branches of technology. (3) An engineer in charge of marking (for cutting, punching, and bending) sheet metal which afterwards is to become parts of cylinders, cones, etc.

Liaison Engineer (1).—One who serves as contact officer between two organizations or two departments of an organization, in an effort to secure high coöperation. Only one found (electrical).

***Locating (Location) Engineer** (9).—One who selects the sites for roads, railways, bridges, transmission lines, pipe lines, manufacturing

plants, or other engineering structures. *Special characteristics:* High appreciation of purpose to which the engineering structure is to be put; skill in interpreting topographical data; knowledge of laws regarding property titles and rights-of-way; feeling for economic aspects of location problems. The locating engineer will spend much of his time in field work.

***Maintenance Engineer** (21).—An engineer responsible for the repair, upkeep, and smooth and uninterrupted performance of plant or equipment or both. *Special characteristics:* Knowledge of standards of performance for plant and equipment; alertness in inspection.

***Management Engineer** (2).—An engineer who devotes himself to the practice of scientific management for efficiency. Synonymous with "efficiency engineer." This is a highly descriptive title, and it is curious that only two men bearing it were found in the study (one mechanical, one mining).

Managing Engineer (10).—An engineer who holds the rank of manager. Synonymous with "executive engineer" or "supervising engineer." Since there is danger of confusing this title with "management engineer," it would be preferable to replace it with such terms as "executive engineer" or "production engineer and manager."

***Manufacturing Engineer** (16).—An engineer engaged in some unspecified phase of commercial manufacture. Manufacturing is the process of making or fabricating anything, especially in considerable quantities, by the aid of many workers or of machinery. The title is virtually synonymous with "production engineer." It should not be used in place of "engineer and manufacturer," or the like.

Manufacturing Methods Engineer (1).—Only one found (mining); a highly descriptive title composed of two functional words. See "methods engineer."

Methods Engineer (8).—An engineer proficient in applying scientific methods to the processes of engineering, in order to secure the most efficient results. The title should preferably be preceded by a descriptive word, such as "mining methods engineer," "manufacturing methods engineer," and the like.

Negotiating Engineer (2).—Perhaps a promotion engineer, perhaps one who negotiates with property-owners for land titles or rights-of-way. Only two found in the study (one civil, one mechanical).

***Operating Engineer** (54).—Same as "production engineer," except that it is used in zones of interest where services or intangible commodities—such as electricity, communication, or transportation—are produced, rather than goods such as engineering structures or manufactured articles. *Special characteristics:* Same as for "production engineer." Operating and production include a large number of the total group of engineers classified by function.

Organizing Engineer (1).—One who coördinates the factors of productive effort in initiating and promoting a coöperative engineering enterprise, or in re-organizing an enterprise which has not succeeded. Although organizing is easily recognized as one of the chief functions of engineering, only one man bearing this title was found (mechanical). *Special characteristics:* Familiarity with finance and the formation of

business organizations; tact and enterprise in negotiating with all the various groups concerned (the group possessing title to the required property, the prospective officers of the company to be formed, financiers, other engineers, and government representatives); executive ability; planning ability; persistence; rigid ethical standards.

***Patent Engineer** (8).—An engineer who serves as an adviser to those who desire to patent an invention. He may deal with such problems as patentability of the device or priority, and even handle some of the legal phases of securing a patent. *Special characteristics:* High ethical standards; knowledge of patent law; familiarity with history of invention; wide technical experience.

Patent-office Engineer (1).—One employed in the U. S. Patent Office. Only one found (mechanical).

Planning (Plan) Engineer (23).—An engineer who outlines a scheme for the practical realization of an engineering enterprise or development. Since almost all types of engineer are required to do more or less planning, this functional title should be modified by some zone-of-interest word to form designations such as "city planning engineer," "telephone system planning engineer," etc. *Special characteristics:* Expert skill in use of the engineering method, including the discovery of all the important factors of a problem and their integration to present an efficient schedule for progress; forward vision; knowledge of methods of forecasting through use of known facts.

Preliminary Plans Engineer (1).—See "planning engineer." Only one found (electrical).

***Production Engineer** (62).—One who supervises the operation of engineering plants producing commodities rather than services. *Special characteristics:* Thorough knowledge of the processes performed by the plant under his supervision; executive skill in meeting a large number of minor emergencies, and experience in maintaining good relations with workers on the job.

Progress Engineer (2).—One who makes periodic reports to executives regarding the current status of an engineering project. Only two found in the study (both civil).

Project Engineer (37).—Although a comparatively large number of men use this title, it is impossible to guess just what function they perform. Presumably the project engineer is a supervising engineer who has the chief responsibility for the execution of a special, unified undertaking which does not fall under any of the routine functions of the managerial staff. However, the term might be used to describe one who originates new projects, or studies and makes recommendations upon proposed projects, or who plans and designs the required plant for an accepted project. The term might also be synonymous with the nonfunctional designation "resident engineer" ("project engineer" is an official title in the Reclamation Service, applied to the chief resident engineer on a reclamation project). In a certain sense, all engineers are connected with some sort of engineering project.

Property Engineer (1).—One who investigates and acquires title to property which his organization desires to purchase. Only one found (mining—probably in the oil division).

Proposal Engineer (2).—Presumably one who studies and makes recommendations on suggestions received for the improvement of his organization's work; or perhaps one who prepares and presents bids or proposals for contracts which his company seeks. Only two found (both electrical).

Publicity Engineer (2).—An engineer who serves as a journalist or advertising man, or who represents his organization at various meetings. Only two found (both mechanical).

***Purchasing Engineer** (8).—An engineer who applies his experience and engineering knowledge to the efficient and economical purchase of materials and supplies required by an industrial enterprise. *Special characteristics:* An encyclopaedic knowledge of the materials of engineering, their prices, characteristics, and tested performance; a business training in dealing with manufacturers and salesmen.

***Rate Engineer** (18).—An engineer who is expert in the field of setting or adjusting rates charged the public for certain services, e.g., freight rates, telephone and telegraph rates, electric power rates, etc. He may be in the employ of the organization providing the services, or may serve on a government commission charged with the supervision of rates. *Special characteristics:* Business training, and a wide experience in the principles of engineering valuation; he may be called upon in court to testify upon the costs of supplying services to the public.

Regulation Engineer (2).—This type of engineer might be (1) concerned with the adjustment of apparatus used in some complicated industrial process; or he might be (2) an engineer serving on a public board for the regulation of public services, utility rates, or the like. Not a very descriptive title. Only two found in the study (both electrical).

Requisition Engineer (3).—One charged with supervising the issuance of supplies requisitioned by other members of the organization.

***Research Engineer** (372).—Research may be defined as "diligent searching for something; careful or critical inquiry or examination in seeking facts or principles." Research is among the top functions of engineering in number of men employed. The research engineer may be required at almost any step in every engineering undertaking, whenever it is discovered that there is a need for facts upon which to base a decision. Primarily, however, the research engineer is one who devotes most of his time to carrying on preliminary study and experiment in an attempt to discover facts that will aid in a more effective application of science to industry. Research, although carried on most frequently in the laboratory, may function equally well in the library, in the field, or on a construction job. There are a large number of research engineers, and the group is expanding. *Special characteristics:* Intellectual honesty, and a high regard for scientific truth; sound knowledge of use of the engineering method; special skill in obtaining and checking facts; ability to carry forward investigations on own initiative. Great skill in dealing with people, or physical ruggedness, is not so requisite in this function of engineering as in some of the others.

Results Engineer (2).—Probably a "progress engineer"; only two found (one mechanical, one electrical). Not very descriptive.

***Safety Engineer** (25).—One who is charged with the duty of protecting industrial workers from physical hazards. The assumption today is that the management is fully responsible for all injuries to workers, since it lies within the power of the employer to maintain a continuous and organized drive for safety and since he has the power to discharge recalcitrant workers who repeatedly expose themselves and others to needless risks. *Special characteristics:* Knowledge of first-aid, industrial diseases, and the literature of safety methods; strategy in securing coöperation of all workers in reducing hazards.

***Sales Engineer** (1003).—One who applies his engineering training to the art of selling engineering goods and services, or who is charged with maintaining engineering relations between buyer and seller. The application of the engineering method to sales and distribution, it is believed, can be almost as fruitful as it has been when applied to design and production. Considered not long ago to lie far outside the domain of engineering, this function has developed remarkably, until at present it enlists far more men than any other of the functional activities. *Special characteristics:* Technical knowledge of product or service sold; pleasing personality and ability to make many social contacts; initiative and perseverance; enthusiasm; use of publicity and promotion schemes; ability to estimate demand of customers for various types of product and to sense market conditions.

Sales Research Engineer (1).—A research engineer who studies market possibilities and trends, and who specializes in obtained facts regarding demand for product and methods of reaching and convincing prospective customers. Only one found (electrical).

***Service Engineer** (53).—A maintenance engineer in the employ of the company supplying the structure or machine used. *Special characteristics:* same as for "maintenance engineer."

Specification (Specifications) Engineer (8).—(1) One skilled in the preparation of detailed plans for contract construction and in making lists of materials required. This function is frequently performed by the designing engineer. (2) One who uses the results of experimental tests as a basis for standards to be met by suppliers of goods and materials.

***Standardization (Standards) Engineer** (6).—One concerned with the creation and maintenance of standard practices in engineering based on efficiency research; an engineer promoting the recognition by industry of standard measurements, interchangeable parts, minimum quality, accuracy of manufacture, and performance of men and machines.

Statistical Engineer (2).—One who deals with large masses of quantitative facts and by the application of statistical methods, draws inferences of value and use in engineering projects. Much of the work of engineers involves estimates of future conditions on the basis of past experience; by the application of mathematical principles, the statistical engineer is able to furnish more valid bases for engineering estimates. Only two found in the study (one electrical, one mining). *Special characteristics:* Thorough knowledge of statistical method for the treatment of facts; ability to present the results of statistical research in clear and accurate form best suited for utilization by those for whom the material has been prepared.

Superintending Engineer (5).—An executive engineer who holds the rank of superintendent.

***Supervising (Supervisor, Supervisory) Engineer** (81).—An executive engineer who directs or supervises the work of other members of an engineering organization, or supervises other engineers. *Special characteristics:* High administrative ability; skill in applied psychology; thorough understanding of engineering technique; appreciation of the aims and policies of the organization.

Survey Engineer (2).—A research engineer who carries on engineering surveys to be used as a basis for future action. He might be assigned to make a sales survey, a survey of future development of a telephone system, or a survey of present methods in a field of industry. Only two found (one mechanical, one electrical). This title should not be used as a synonym for the zone-of-interest title, "topographic engineer."

***Testing (Test) Engineer** (143).—One who carries out tests of machines or materials used in engineering, or who tests the products of an industry—e.g., chemicals, metals, instruments, building materials, automobiles, etc. *Special characteristics:* Knowledge of current techniques in testing of machines and materials; knowledge of quality and performance standards; methodical habit of recording and summarizing results of tests.

Time-standards Engineer (1).—An efficiency engineer who, by the aid of time-studies, works up standards for rates of performance. Only one found (mechanical).

***Time-study Engineer** (8).—An efficiency engineer who studies the amount of time required by industrial operations under various conditions of work, in an effort to reduce human toil by the elimination of unnecessary and wasteful movements, and through the use of more efficient machines and processes. *Special characteristics:* Knowledge of the literature and practice of efficiency engineering; ability to ingratiate himself with men on the job; a realization that theoretical considerations of efficiency must be backed by knowledge of practical limitations.

Training Engineer (1).—A personnel engineer in charge of training new employees, or perhaps a young engineer who is taking instruction in the performance of his future duties; not clearly descriptive. Only one found (mechanical).

***Valuation Engineer** (68).—One who estimates the value of an enterprise or the value of property, plant, or equipment. Valuations may be made for the purposes of financial statements, taxation, rate-making, purchase, capitalization and issuance of securities, and for estimating the probable profit of a contemplated enterprise. *Special characteristics:* A knowledge of engineering economy, accountancy, and depreciation; practice in obtaining facts and figures required for reliable estimates of value; skill in making financial reports; an understanding of modern theory of valuation of public and private works; sound technical training and engineering experience.

Zoning Engineer (1).—An engineer employed by a municipal or other governmental agency to make recommendations regarding the restriction of certain areas or types of buildings, in order to obtain a planned result. Only one found (civil).

AN ALTERNATIVE METHOD FOR THE CONDUCT OF AN ENGINEERING COURSE *

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The typical course, from which there is only slight departure in American engineering schools is one whose virtue is discipline and whose vice is rigidity. These two qualities seem to go hand in hand. To preserve the one, we retain the other. Granted that detailed accomplishment may readily be made the basis of excellent discipline, that the requirements of weekly reports and daily problems are so easy to enforce that this discipline may as easily be maintained, it seems to follow naturally that a rigid regime must result.

By rigidity is meant the fixed program of required studies and especially the four years and 150 credits which yield the Bachelor's degree. This fixed program is composed as everyone knows, of the fundamentals of physical science, applied science and technology, english, economics and little if anything else. The four years is a traditional time-period between graduation from high school and from engineering college. So strongly is this particular extent of time fixed in the popular mind that so far it has been practically impossible either to lengthen or to shorten it except for the needs of irregular or deficient students.

The Bachelor's degree is given for four years, no more, no less. For a student to require more stamps him as inferior; if the ground could be covered in less time, it may be assumed that more labor would be demanded in the interest of raising the standards of the course. Perhaps four is the magic number that spells perfection when applied to the duration of a course, but if not, then the firmness with which it continues to maintain itself may be ascribed not to any inherent virtues but to the following causes: (1) established custom, (2) conservatism of school administrators and faculties most of whom have undergone the same experience, (3) influence of the state universities which have been able to offer the standard course with low tuition charges, (4) the tradition of Commencement and Bachelor's degree after four years of any kind of collegiate course.

* To be presented at the Conference on Electrical Engineering at the S. P. E. E. meeting, University of Wisconsin, June 23–26, 1936.

The 150 credits imply the departmentalizing and subdividing of the work to be done. The class unit is the hour or fifty minutes. The student goes from class to class, from subject to subject and from course to course, one hour here, one hour there, "precept upon precept, line upon line, here a little, there a little."

As the various subjects gradually unfold he must endeavor to fasten them in his mind, 6, 7, 8 or 9 of them all in parallel. Is it not common experience that when the class begins to study electric circuits the physics lessons of the preceding semester are found wanting? And is it not common observation that too many of the students quickly lose their mental alertness in class and lapse into a state of passive absorption?

This departmentalizing and subdividing have a tendency to develop a set of tight compartments with each subject separated from its neighbors. In the case of a single course, the required problems are handed in (often more than an average student could possibly work by himself), the hour tests and the final examination are passed, successfully, let us assume, with the aid of much cramming, and the course is put away on the shelf but not for future reference.

Without attempting to describe further a state which has existed many years and to which we are all rather comfortably adjusted, it may still be desirable to draw a distinction between the prevailing system as it applies to the Engineering School and to the Academic College. The difference lies in the fact that in the college the amount of work required of a student is far less, and this enables him to spend a considerable portion of free time in following his interests whatever they may be, intellectual, social, or athletic. There is a freedom of the college student which scarcely exists for his engineering neighbor, a freedom which is often abused, but still a freedom, and essentially a thing of great potential value.

The Academic College has its own problems and I would not for a moment hold its practical procedure up as a model for engineering schools. But the latter demonstrate some of the efficiency that is possible under a dictatorship while the former exhibits the weakness—and the strength—of a democracy. Can we not somehow bring together these elements of efficiency and democracy into the work of the engineering schools?

Our trouble with our electrical courses is that we have given up valuable features in order to add other valuable features. Within a single subject such as chemistry or physics, much new material has been added that was unknown to a previous generation. To get it in, the work must be speeded up or other matter must be dropped out. Both have happened for it is not true that students now work harder or do more than they did twenty years ago.

Speeding up consists rather in loss of thoroughness as well as elimination of details deemed to be of lesser importance. In some cases there has been redistribution of time allotted to various courses the total amount of time remaining the same. Courses involving drawing have been cut down, also shop work, laboratory and free electives, and modern languages have been practically eliminated. The required thesis, the one opportunity a student had to relate himself to original research, has been largely suppressed. These reductions and eliminations have come about partly because of changing emphasis, partly because of the necessity to crowd into the four-year course new subjects such as radio, and now electronics, and partly because the inherent values to be found in some subjects, especially laboratory, have not been fully comprehended.

If the above discussion gives in outline a fair picture of what we do, and if our present procedure is called into question, it becomes pertinent to make inquiry as to our real objectives. In other words, what are we really trying to do?

There are those who feel that our job is to turn out Electrical, mechanical or civil engineers. We are to forget about humanities, about culture and about citizenship—these are not our affair. No doubt some who take this position go so far as to favor leaving out the study of english and economics in order that their places may be given to more mathematics or science or technology.

On the other hand we find some who feel that the engineer is not taking as prominent a place in affairs generally as they think he is fitted to take. They say this is partly because he cannot express himself well, cannot "put things over," has not the broad interests and cultivation necessary to high attainment and influence in the world at large. They feel that what he lacks should in some way be supplied by his engineering course which, in turn, should be characterized by greater breadth and more particularly by additional study of english.

It is not my purpose to try to strike a balance between these points of view, but whichever way we lean, it remains a question whether there is any possible way of doing much of anything with the course so long as it continues to be predicated on four years and 150 credits.

Let us then imagine that the four years and 150 credits are to be removed entirely from consideration, that we are no longer to pay any attention to them, and then let us see upon what other basis a course might be devised which would give such a degree of flexibility, for example, as to permit study of a foreign language, or which might allow of some concentration upon topics of especial individual interest. Let us see if, at the same time, this new course

could be so devised as to retain also the advantages of the discipline that comes with hard work.

The first requirement of the new course should then be that it involve no system of credits. As soon as this specification is adopted we are free to proceed, but the elimination of credits immediately requires that there must be found some test to determine when the course as a whole has been completed. This test would very reasonably consist of written and oral examinations together with reports and records of work done which puts the emphasis where it belongs, namely on the student's actual accomplishment, and not upon his credits. Students might be privileged to present themselves at any one of several stated times a year for the examinations and this would destroy the fixity of the present four year period.

The next requirement relates to the methods of conducting the work, for such a system as we are trying to construct could hardly consist of a lot of independent compartments of lectures, recitations and laboratory exercises arranged in the usual schedule form. Time may have cast a halo around these vehicles of learning which have some times been guided by very skillful professorial drivers. It is not, in fact, so much a matter of type of instruction that we find fault with, as in the habitual use of that type. We have overdone classroom work, especially with juniors and seniors. Lectures indeed, should have their place in the new order, but they should be relatively few and very well prepared, and the student should obtain from them general pictures, relations and proportions, appreciation of values, etc.

Recitations are of the nature of oral examinations but very inefficient ones. They should be practically eliminated. In their place the individual students should be given assignments on which to work and report. This can hardly be done with satisfaction on the hourly period plan, but would require that each student have his assigned place to work and be expected to be on hand and at work during the working part of the day. He would appear each morning at, say, 8:30, and proceed with his work until noon. Again in the afternoon he would work from 1 to 4:30. Naturally he would not sit at a desk all this time; his day would include some problem working, some looking up of references and writing of papers and some laboratory, the work being for the most part individually assigned. Now and then a lecture would be given and at intervals he would be called on to demonstrate problems before a class or group. And what about the professor? He would be supervisor in chief of his particular subject and would keep in constant touch with the progress of the individual students whose work would be more directly followed by a sufficient number of

assistants. To avoid paralleling so many courses as at present there would be periods of concentration on the subjects studied.

It is not my purpose to describe in detail how this course would be put into practice for two reasons, first, because it is important that attention be concentrated on the general principles and second, because in applying them different persons would work out quite different programs.

Nevertheless it seems desirable that an attempt be made to give objectivity to the method, and I shall, therefore, try to describe briefly one way in which it might be applied. We will assume that the senior class only is to be changed over from the old system, the other classes remaining as before for the present. The senior electrical class to which we will devote our attention, consists of twenty men. These will be divided into two equal groups, each group being assigned a room and each student given a desk. These two divisions may be made according to ability or in any other way desired, but in this instance the division is into those more mathematically inclined on the one hand and into those more mechanically inclined on the other hand.

The two divisions are further divided into four groups of five each, and an assistant is placed in direct charge of each group, and all four assistants are under the direction of the professor.

The year starts with the subject of Alternating Current Machinery, and each student learns that he is to be held for a good working knowledge of the subject matter as represented by one or more specified texts together with practical studies of operation of the machines in the laboratory. First may come a lecture, introductory in character, with instructions and assignments. The assistants then take hold and more or less coach the students through the book, assigning problems and explaining their difficulties. At certain times the work is carried on at the desks, while at others it is in the laboratory. This work in Alternating Current Machinery is the only electrical work being done by these students at that particular time, and an average student might expect to complete it in thirteen weeks at the rate of eight hours per day and four days per week. The remainder of the week is divided into more formal work periods according to the subjects the student desires to elect.

Student A, a bright, quick, energetic fellow, covers the subject matter of the book in eight weeks, and the professor guides him into an interesting research problem which challenges his abilities. Student B, with a particular liking for mathematics, is brought more directly into association with one of the mathematics professors who encourages him to extend his general grasp of that subject especially in its relation to engineering problems, and in so doing,

though an excellent student, he continues some fifteen weeks before finishing the book. Student C has a flare for experimental work and he makes his approach to mastery of the subject through the laboratory. Student D learns slowly and leans rather heavily upon the assistant. The latter impresses upon him the necessity of giving his work the character of thoroughness, reliability and neatness, qualities within the reach of less brilliant minds, and therefore most essential to their future success. Student E finishes his work in an average way, without much enthusiasm. He is spurred on, however, by the hope of being soon in a position to work in the field of radio which is his especial interest. When he has completed the study of electrical machinery to the satisfaction of the professor in charge, he goes directly into the study of radio under the direction, possibly, of a radio specialist and with the same assistant following his work.

It will be seen that with this approach to the proposed method, all students start together at the beginning of the senior year. Were the beginning to be made with juniors, the seniors would not start together, but some would be well along in Alternating Current Machinery before reaching the fourth year. The student's complete record shows in sufficient detail what he has done, and likewise reveals what he has not done. When the department is convinced that sufficient ground has been covered, the student is permitted to register for the final covering examination which is set four or five weeks ahead giving time for general preparation including reports on any special problems of research or other matter which it is desired that he submit to the examining board.

Students who have successfully passed all requirements are then in position to be considered for appointment to the post of assistant, and, if so appointed should spend at least two years in that capacity, carrying on, at the same time, advanced study towards a higher degree.

Something remains to be said about the functions of the professor. He would occupy a position more analogous to that of the Director of a division of a Research Laboratory. No more time would be required for conducting recitations, but more and more he would concern himself with the conduct of research investigations in which his students would participate, or if his abilities were not along research lines he would perhaps be engaged in some practical engineering problems relating to present day developments or engineering economics.

Such, in brief, is an outline of what might be called an alternative method in technical education. It is so very different from the usual one because it departs from the traditions of classwork as carried over from the secondary schools, that no fair comparison

could be made except after a thorough trial. Whether such a proposal as this would possess the desired attributes of discipline and flexibility can only be conjectured, but, granted a faculty of wise and competent and perhaps a trifle venturesome teachers, is there any reasonable ground to question the possibility that its successful operation might give new life to the technique of Engineering Education? However, the newness of the idea is in its application to higher education, for it gets its inspiration not from the secondary schools but from the organization and conduct of an Engineering Research Laboratory.

A NEW GENERAL ENGINEERING CURRICULUM*

A Composite Course of the Basic Technical Engineering Elements of General Civil Engineering, Power Electrical Engineering, Industrial Engineering, and General Mechanical Enggineering

By ALBRECHT NAETER

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During the depression it became increasingly apparent everywhere that often there was little correlation between an engineer's specialized training and his industrial engineering work. This same lack of agreement is very evident in the published results of the engineering profession as prepared by the American Engineering Council from the 1930 Census. There has also been an increasing demand, in the past few years, on the part of Oklahoma industry for a more generalized training for engineers than is available under the specialized engineering curricula.

About two years ago I suggested in a meeting of Engineering Department Heads at Oklahoma A. & M. College that I thought the time was ripe for the consideration of a new type of engineering training. I proposed that it should consist of the basic technical engineering elements of civil, electrical, industrial, and mechanical engineering. The plan was taken under consideration for study by the departments affected. Several educational papers that have a pertinent bearing on the new curriculum have been published in *Electrical Engineering* in the two-year interval since I first proposed it.

In a paper entitled "Industry Demands and Engineering Education," L. W. W. Morrow emphasized that industry of the present and the future demands a large number of engineers for operation and management and only a small number for highly specialized engineering and research.

A paper, very significant in its implications on the new engineering training of the future, was presented by past-president Wm. McClellan as an A. I. E. E. 50th Anniversary discussion of "The Growth of a Profession." McClellan contrasted the unity of purpose and training of the legal, the medical, and the ministerial professions with the present endless diversification of the engineer-

* To be presented at the Conference on Electrical Engineering at the S. P. E. E. Meeting, University of Wisconsin, June 23–26, 1936.

ing profession. However, he emphasized that in spite of the numerous so-called engineering specialities, "from the engineering standpoint, they all ought to have a broad, fundamental knowledge of strength of materials, thermodynamics, electromagnetic induction, hydraulics, flow of gases, and other basic underlying features of all engineering development." The speaker, in his anniversary address, said further that if this fundamental training is given, "any college graduate cannot do more, in the last two years of his course, than some specializing just exactly as the doctor in his four years' course in medicine and surgery may specialize during his last years in certain kinds of medicine or surgery." However, upon graduation all of these young doctors receive the same degree thereby emphasizing first of all the fundamental unity of their profession.

This growing sense of the essential uniformity of engineering training is receiving support from another source that is likely to bring much pressure to bear, in time, upon the types of engineering curricula offered by colleges and universities of the near future. Engineering license legislation has been passed by a majority of the states in the union. Oklahoma joins their ranks this year. The Oklahoma law is similar to that of many other states in that it licenses engineers as professional engineers without indicating the nature of their respective specializations. Even though this feature of the law is so designed for the protection of the public, it is certain to stress the essential unity of the engineering profession. The first registration board has represented on it a majority of the engineering specializations active in this state.

As a byproduct of the Oklahoma license legislation, an Oklahoma Society of Professional Engineers is now being formed. "The purposes for which this Corporation is formed are to: (*a*) Develop and maintain high professional and ethical standards among its members in their relationships with the public and with each other; (*b*) Promote the general welfare of the professional engineers of Oklahoma; etc." It is very likely that in time this organization will have much influence in consolidating the interests of the specialized groups, and in promoting the fundamental unity of requirements for securing licenses. This, in turn, will react upon the types of examinations set for licenses, and this will affect the college programs of engineering study.

After the suggested engineering curriculum was accepted in principle for the purpose of study, numerous committee meetings were held in order to select from each department the most suitable courses of study. The members of the committee were of the opinion that the new program should give a more general training than is now offered in any one particular branch of engineering. They

accepted my original suggestion that the plan of study should be technical in content rather than managerial, the latter being a characteristic of many so-called general engineering courses that are now offered. Finally, the committee agreed upon a composite course containing the basic technical engineering elements of general civil engineering, power electrical engineering, industrial engineering, and general mechanical engineering.

In its deliberations the committee was guided materially by some statements made by W. E. Wickenden, as Director of Investigation for the Society for the Promotion of Engineering Education, in his "Preliminary Report to the Board of Investigation and Coördination and the Society." He said: "The engineer of tomorrow will not rise to leadership by abandoning his distinctive rôle or by permitting it to become ill-defined. He will do so by remaining essentially an engineer, by becoming a more competent engineer, by extending the reach of engineering methods and ideals to larger realms of life, and withal, by making himself a team-mate eagerly desired by other types of men. If engineering education is to serve these ends, it must safeguard all the distinctive qualities and virtues of its past and add to them a more general humanism."

It is felt that some safeguards would be necessary to keep the new course from becoming a "haven for lame ducks." To start with, each of the specialized engineering curricula at Oklahoma A. & M. College is patterned strictly in accordance with the recommendations of the Society for the Promotion of Engineering Education. Also, this new course contains essentially all of the courses required in the first three years of civil, electrical, industrial, and mechanical engineering, in their normal sequences. Since, in each case, the general engineering student is placed in the same classes with the particular specialized departmental students concerned, he is treated as a major student in that field and is expected to meet its requirements. Hence, there are no service courses in engineering for the general engineering student.

To meet this double duty for departmental courses in the future, the sequences of topics, and not the amounts of material, have had to be changed in only a few cases in specific departmental subject matter courses. This was done without weakening the contents of the courses for the specialized students. With these changes accomplished, no additional teaching loads and concomitant costs are imposed unless the new plan of study should attract students who otherwise would not have come to this college.

To strengthen the curriculum, senior level subjects from each of the four departments are included. As a further guard against "lame ducks," the graduation requirement was made 148 semester hours instead of 144 as in the specialized departments.

Particular attention should be paid to the method of administration of this new course. A new Department of General Engineering was organized with the Dean of Engineering as its Head. He is to be assisted by the heads of the four coöperating engineering departments and other staff members as needed. This organization prevents any feeling that General Engineering is a part of any specialized department, and insures excellent supervision.

New General Engineering Curriculum

These various considerations led to the formation of the following curriculum (in each case the last digit in the course number indicates the number of semester hours credit):

Freshman Year

Math. 144, College Algebra
Math. 112, Plane Trigonometry
Math. 124, Analytics
Chem. 114, 124, General Chemistry
M.E. 124, Descriptive Geometry
M.E. 112, Engineering Drawing
Engl. Comp. 113, 123, Freshman English
Shop 241, Forge and Heat Treatment
C.E. 124, Surveying
Mil. Sci. 111, 121, Military Science
Engr. 110, 120, Engineering Lectures (Orientation)

Sophomore Year

Math. 215, 223, Calculus
Phys. 215, Mechanics and Heat
Phys. 225, Electricity, Sound, and Light
Chem. 283, Chemistry of Engineering Materials
C.E. 213, Mechanics, Statics
E.E. 212, Introduction to Electrical Engineering
E.E. 225, Electric, Magnetic, and Dielectric Circuits
I.E. 312, Manufacturing Processes
M.E. 213, Kinematics and Mechanisms
Mil. Sci. 211, 221, Military Science

Junior Year

C.E. 315, Strength of Materials
C.E. 352, Highway Engineering
C.E. 374, Reinforced Concrete
E.E. 324, Alternating Currents
Geol. 214, Engineering Geology
I.E. 313, 323, Industrial Organization
M.E. 313, Steam Power Plants
M.E. 311, Steam and Gas Laboratory
M.E. 323, Thermodynamics
M.E. 353, Machine Design
Shop 261, Machine Shop Practice
Engr. 300, Summer Practice

Senior Year

Engr. 411, 421, Seminar
C.E. 344, Elements of Structures
C.E. 453, Highway Bridges
C.E. 333, Hydraulics
E.E. 434, Alternating Current Machinery
I.E. 311, Time Study
M.E. 413, Internal Combustion Engines
Acctg. 424, Accounting for Engineers
Econ. 433, Economics for Engineers
Engr. 400, Inspection Trip
Electives, 10 semester hours

Industrial Survey

The members of the committee felt that it would be advisable to feel out industry for their reactions. The proposed curriculum was sent to prominent employers in the Oklahoma oil and gas industry, accompanied by a set of four specific questions. These questions, and their answers, all of which were similar, were well summarized by Professor C. A. Dunn, in an Oklahoma Engineering Experiment Station Bulletin on the New Engineering Curriculum, as follows:

(1) Does the industry you represent need young engineers trained along a specific line such as mechanical engineering, civil engineering, etc., or will a man generally trained be desirable?
Answer: In general, young engineers do not need specialized training.

(2) Will graduates with a broader training have more opportunities in your field than one of the specialized graduates?
Answer: Yes.

(3) Will it be necessary for those taking this proposed course to obtain a fifth-year degree in one of the departments to have an equal chance for employment?
Answer: No.

(4) Will the future of these graduates contain as many opportunities as the fourth-year specialized man?
Answer: More.

The oil and gas industry was chosen, because it is the largest employer of engineers in the state of Oklahoma, considering numbers already employed, and present employment programs.

Provision for Specialization

As the study progressed, it became apparent that some graduates, after having received their Bachelor of Science degrees in engineering upon completion of their general engineering course, might wish to specialize immediately in their studies. Others might desire to return to college for their specialized study after some years of experience in industry.

Accordingly arrangements have been made with the coöperating departments of civil, electrical, industrial, and mechanical engineering whereby a student upon completion of his requirements for the degree of Bachelor of Science in Engineering can obtain the Bachelor of Science degree in any of the above-mentioned departments upon completion of an additional year's work. The members of the committee were agreeably surprised to find this specialization possible in so short a time.

After the graduate of the four year course in general engineering has decided that he wishes to specialize in some particular branch of engineering, either as a result of finding himself in college or of becoming oriented in industry, he may then make his choice of specialization. The committee examined several existing curricula, made up of composite courses of the same four coöperating departments and offering fifth-year specialization, but in every case the choice of specialization had to be made not later than the beginning of the senior year. The *after-graduation* choice represents a decided advantage over the senior-year choice in that the general engineering graduate has then had more of a chance to become oriented.

While the study of the committee was developing, it was urged by some that course material of one or more additional departments should be added to the new general engineering curriculum. Examination soon made it clear that this addition would remove the after-graduation choice of specialization with its concomitant completion of specialization in a particular branch of engineering in one year's time. Hence, the new curriculum was limited to four departments. Also, some departments, such as chemical engineering and architecture, require so much specialization to insure a reasonable chance of professional success that they do not lend themselves so readily for use in a composite program of study.

In line with the general trend towards cultural training for engineers, provision was made for 10 semester hours of electives in the senior year. Even though the technically inclined student may wish to get a certain amount of specialization through careful use of electives, yet the electives may be made up entirely from subjects not of an engineering nature. In fact, cultural subjects are recommended.

Name for New Course in Engineering

The members of the committee debated at length concerning the choice of a proper descriptive name for this new engineering curriculum. They felt that "basic" engineering most nearly described the content, but recognized the fact that this term had no generally

accepted meaning in either the engineering world or in industry. At the same time, the committee realized that general engineering, in its ordinary usage, connoted considerable emphasis upon managerial studies, and usually a wide range of electives in liberal amounts. Finally, it was decided that perhaps it was best at first to label it, in the college catalog, as General Engineering with the subtitle description of "composite course including the basic essentials of civil, electrical, industrial, and mechanical engineering."

Conclusions

This new engineering department is *not* intended to replace present departments, but is added to give a more general technical training than is now available in any one particular branch of engineering. It should meet admirably the requirements of the operative and managerial group of Morrow's report. At the same time, some of our faculty members believe that it should also form a good foundation for specialized training. When specialization is placed on the firm foundation of this new general engineering course, then it meets Wickenden's ideal in that this "professional education for engineers is not a separate route, but a second mile" built upon a thorough functional training for the large operative and managerial group. In line with Past-President McClellan's address at the A.I.E.E. 50th Anniversary Convention, this new type of training may form the nucleus of a united engineering profession.

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NEW MEMBERS

BENNETT, ALBERT A., Professor of Mathematics, Brown University, Providence, R. I. W. H. Kenerson, F. N. Tompkins.

CALDWELL, WILLIAM M., Instructor in Mechanical Engineering, Pratt Institute, Brooklyn, N. Y. F. L. Schwartz, R. Burdette Dale.

CAMP, THOMAS R., Associate Professor of Sanitary Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. B. Breed, K. C. Reynolds.

CARTER, EMMETT B., Consulting Engineer on Industrial Plant Management, 162 Engle Street, Tenafly, N. J. C. E. Davies, Joseph W. Roe.

CATHER, CARL H., Assistant Professor of Mechanics, West Virginia University, Morgantown, W. Va. G. P. Boomsliter, R. P. Davis.

COOPER, ALBERT H., Assistant Professor of Chemical Engineering, North Carolina State College, Raleigh, N. C. J. W. Harrelson, E. E. Randolph.

DILLMAN, GROVER C., President, Michigan College of Mining and Technology, Houghton, Mich. G. W. Swenson, C. H. Baxter.

DOLL, THEODORE, Assistant Bridge Engineer, A. T. & S. F. Railway, Chicago, Ill. Wm. C. Bauer, Wm. G. Smith.

DOWELL, DAWSON, Associate Professor of Mechanical Engineering, Drexel Institute, Philadelphia, Pa. F. L. Bishop, Nell McKenry.

GAMET, MERRILL B., Instructor in Civil Engineering, Northwestern University, Evanston, Ill. Herbert Philbrick, Wm. H. Burger.

GOETZ, BILLY E., Instructor in Economics, Armour Institute of Technology, Chicago, Ill. J. B. Finnegan, D. E. Richardson.

GRANEY, MAURICE R., Instructor in Practical Mechanics. Purdue University, Lafayette, Ind. J. N. Arnold, J. D. Hoffman, Justus Rising.

HARRINGTON, LOUIS C., Dean, College of Engineering, University of North Dakota, Grand Forks, N. D. F. L. Bishop, Nell McKenry.

HENIKA, JOHN H., Foreman, Wood Laboratory, Georgia School of Technology, Atlanta, Ga. D. P. Savant, W. V. Dunkin.

HESS, WENDELL F., Assistant Professor of Electrical Engineering and Physics, Rensselaer Polytechnic Institute, Troy, N. Y. Stanley B. Wiltse, James Devine.

HILL, FRANCIS M., Instructor in Engineering Drawing and Mechanics, Georgia School of Technology, Atlanta, Ga. O. D. Holland, P. B. Narmore.

HINMAN, JACK J., JR., Associate Professor of Sanitation, State University of Iowa, Iowa City, Iowa. B. J. Lambert, E. W. Lane.

HOLMAN, LEON W., Instructor in Architectural Engineering, Los Angeles Junior College, Los Angeles, Calif. Clarence E. Guse, John W. Hazen.

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LOEW, EDGAR A., Dean, College of Engineering, University of Washington, Seattle, Wash. E. A. Holbrook, F. L. Bishop.

MORRIS, WILLIS D., Assistant Professor of Electrical Engineering, Louisiana State University, Baton Rouge, La. F. H. Fenn, M. B. Voorhies.

PUBLOW, HENRY E., Professor of Chemical Engineering, Michigan State College, East Lansing, Mich. H. B. Dirks, L. S. Foltz.

SALZER, GEORGE W., Professor of Descriptive Geometry and Engineering Drawing, Colorado School of Mines, Golden, Colo. F. L. Bishop, Nell McKenry.

SEAR, ARTHUR W., Assistant Professor of Electrical Engineering, Armour Institute of Technology, Chicago, Ill. E. H. Freeman, C. A. Nash.

TAYLOR, WILLIAM H., Associate Professor of Engineering Drawing and Surveying, University of Alabama, University, Ala. G. J. Davis, D. P. duPlantier.

VALADE, ERNEST A., Dean, School of Engineering and Architecture, Catholic University of America, Washington, D. C. John R. Lapham, F. L. Bishop.

WHEATON, HERBERT H., Associate Professor of Mathematics and Engineering, Fresno State College, Fresno, Calif. H. E. Davis, R. E. Davis.

WILHELM, RICHARD H., Instructor in Chemical Engineering, Princeton University, Princeton, N. J. A. M. Greene, Jr., Jos. C. Elgin.

236 new members

SECTIONS AND BRANCHES

The Sixth Annual meeting of the **Arkansas-Oklahoma Section** opened with a dinner at the Faculty Club, which was attended by 48 members and guests. After the meal President Clyde L. Farrar introduced Acting Dean F. G. Tappan of the University of Oklahoma, who introduced Dean and Mrs. Donnell of Oklahoma A. & M. College. Dean Tappan expressed regret that illness kept Dean Gladson of Arkansas University from the meeting. He also extended a cordial welcome to all the guests. Responses were made by Professor Spence of Arkansas and by Dean Donnell of Oklahoma A. & M. Both expressed the belief that much good comes from the social contacts made in meetings such as this where all members were interested in the solution of the same general problems. Dean Donnell also issued an invitation for all to be present next year when Oklahoma A. & M. College is to be host.

The business meeting was called to order by President Farrar. The minutes of the previous meeting were read and approved. The committee on Constitution and By-laws recommended that no changes be made.

The nominating committee consisting of E. R. Page of O. U., R. E. Means, Oklahoma A. & M. College, and L. C. Price, University of Arkansas, made the following nominations: For President, Professor R. G. Saxton and Professor E. C. Baker; for 1st Vice-President, Professor W. R. Spencer and Professor R. G. Paddock; for 2d Vice-President and Chairman of the Program Committee, Professor J. C. Davis and Eugene Dawson; for Secretary-Treasurer, Professor C. R. Wood and Professor DeWitt Hunt. There being no nominations from the floor the nominations were declared closed and the names submitted were balloted upon using a single ballot. The results were: President, R. G. Saxton; 1st Vice-President, Professor W. R. Spencer; 2d Vice-President, Professor J. C. Davis; Secretary-Treasurer, Professor DeWitt Hunt.

A telegram was ordered sent to Dean W. N. Gladson, expressing regret for his illness and wishes for his speedy recovery. Dean Tappan and Dean Donnell were appointed to draft and send it.

Assistant Dean G. W. Whiteside, of Oklahoma Agricultural and Mechanical College, read the first formal paper on Saturday morning on "Administrative Helps for Improving Teaching Efficiency," which was followed by formal discussion by Professor

Stelzner, University of Arkansas, and Dean F. G. Tappan, University of Oklahoma.

Professor Stelzner said: "There is no use in denying students graduation on account of poor English unless some definite effort is made in the first three years of college work to correct the fault.

"An instructor may demand a disproportionate amount of the students' time, and something should be done by the administration to coördinate efforts along this line so as not to require too much of the students.

"The matter of awarding honors should be studied. Unless this problem is handled with a certain degree of thought, it may be responsible for the creation of wrong conceptions and ideals. Student winning honors may get a wrong impression of his own ability.

"The major problem for administrators to handle at the present time and in the near future has to do with the general attitude of the student, which seems to have changed. The type of work the student is doing has changed. It is more the problem of finances. It is probably due to the attitude the public in general is taking with reference to our young people. We can go too far in our efforts to do everything for them. If we make it too easy for the students, it leaves them no room for development. We should put more obstacles in their way, making them as realistic as possible. If the administration handles the problem properly we will have the development of students that we may expect."

Professor Tappan made the following remarks: "What do we mean by teaching efficiency? Increase of output over input? Facts acquired over facts offered?

"A good grasp of English should be secured before reaching college. It is hard to change a student fundamentally in regard to thinking after having had six or eight years of home life of a certain type.

"What does teaching efficiency mean? It shouldn't be based on hours credit or number graduating. About 70 per cent of freshmen become sophomores. Of course there are additions, transfers, etc. The mortality as far as engineering freshmen is concerned is very high.

"Engineering education should be conducted in some ways as a business and in some ways it should not be.

"Engineering is a type of mind recognizing the problem, analyzing it, and then organizing with men, materials and money to carry it through to a successful conclusion.

"A mere accumulation of facts, of credit hours does not make a good engineer. It is very difficult to get students to reason or think things out except in stereotyped form.

"An increase in teaching efficiency might mean increasing the quality of the students, cutting out the lower 30 per cent for freshmen, 10 per cent for sophomores, etc., but this cannot be done mechanically. The more organization you have sometimes means the farther you get away from real teaching. Some departments have too much system. This does not leave the student room to think.

"The standards have changed a great deal. Things expected of juniors now were considered as graduate work in 1904. We are requiring more and more of our students. We are adding to the curriculum too much of historical matter that should have been dropped out at some time in the past.

"Our freshman conference this year has been meeting one hour a week. It met five times during the first semester and will meet eight or twelve times this semester. We have introduced a slight variation this year from the usual custom of having all the talks given by heads of the various engineering departments. We have had a number of talks by heads of departments outside of engineering entirely. Most of the speakers related their talks to the general field of engineering.

"The problem of student finances is also an acute one. Most of the students who are dropped and reinstated because of failure in forty per cent of their work were working too much and carrying too many hours. The tendency is for students in engineering to take too much work. The administration has tried to supervise the student in this respect in a way through his adviser.

"We should try to teach a student to recognize a problem and then analyze it, in short to think.

"As far as moral conduct is concerned we think we know all of it and don't try to learn anything. The same may be applied to the teaching field. Orthodoxy is the death of teaching. To increase the efficiency in teaching we should strive to teach the scientific attitude, the way to attack problem rather than trying to make the student memorize a number of facts which they immediately forget after they have graduated.

"I agree with Whitesides that every worthwhile administrator is willing to exert every effort to get better engineering graduates, which includes the requiring of an attitude of mind to apply facts."

The next paper, entitled "A Survey of Methods for Evaluating Teaching Efficiency," which was prepared by Professors R. G. Paddock and G. P. Stocker of the University of Arkansas, was read by Professor Paddock.

R. L. Huntington, of the University of Oklahoma, said: "We should remind students once in a while what engineering really is —the application of the fundamental sciences, physics, chemistry

and mathematics, to the welfare of mankind. A student is not a real engineer unless he has these things really at hand and applies them for the welfare of humanity.

"W. T. Lewis of the Massachusetts Institute of Technology is a strong supporter of the problem method of teaching engineering. He believes in problems the solution of which is not obvious on first sight, practical problems that call for considerable analysis. The difficulty is that this method slows down the rate at which you can cover material. I would like to see the honor system adopted. It is hard to give students engineering problems which really test their ability unless they can take ten or fifteen hours to solve them.

"I agree that research is stressed too much in rating the ability of engineering teaching. The reason for recognizing research is that the student has material handed to him for four years during his college work. In research work the student begins to apply things he has learned. If more research were given him he would be ready for bigger jobs when he gets out. The industry is looking for engineering graduates who are keen to explore the unknown.

"Professors should keep in touch with the market for their product. Contact with industry is quite necessary.

"The weeding out process in the student body should take place in the freshman or sophomore year."

L. E. Hazen, Oklahoma A. & M. College, spoke as follows: "I have my own methods of evaluating teaching efficiency.

"I never worry about the objective of the course. All I worry about is to give the students two perspectives—a general idea of the subject matter, and a first hand knowledge of the working tools.

"The student has two objectives in coming to college—to get an education and to get a degree. They are not necessarily the same.

"There are four things to contend with in students: (*a*) past experience; (*b*) fixed habits; (*c*) English; (*d*) natural bent.

"Success in life consists of two lines. The first type of successful person is one who can do something that no one else can do. A student of this type is a special problem. The second type of success is doing better than any one else that which any one else can do.

"One way I judge whether my teaching has been effective is to question the students when they come back from their vacations. I inquire as to how many of them have performed some sort of agricultural engineering while on their vacation."

The last paper "The Effect of Personality Upon Teaching Efficiency," prepared by Professor J. F. Brookes, of the University of Oklahoma, was read by Professor J. E. Smay, of the same University.

L. C. Price, University of Arkansas, said: "Personality traits are outer evidences of the inner being. Traits of character are humility, sincerity, devotion to duty, high moral standards, an understanding heart. Sometimes all are combined in one man. Most of us must give some attention to deficiencies in our personality. We should, however, avoid overemphasis of surface traits.

"Referring to Mr. Brookes's statement concerning 'painless teaching.' A student may be too dependent on his teacher. He must avoid coddling the students. The shallow student will be held by surface traits. Deeper students will be attracted by deeper traits. All of the qualities named above are desirable. Everyone should examine himself for faults and correct them. However, too much worry about surface qualities may endanger real qualities.

"Men of real character may be deficient in some of the surface qualities but this will not be noticed after one becomes well acquainted with them. The man who has character qualities need not worry about the others."

H. G. Theusen, Oklahoma A. & M. College, said: "Painless teaching means a maximum amount of learning with a minimum amount of effort. If a person scrutinizes himself too carefully he may get too introspective. If one has the correct philosophy the personality will take care of itself.

"The student is a human being and should be treated as such. The faculty makes rules but they should be made for the benefit of the student. It should be a sort of benevolent autocracy.

"There is no objective method by which teaching can be evaluated. We should be interested in the mental attitudes of the student, those he has and those he acquires while in college. The teacher should have the realization that the engineering profession isn't to be put on a pedestal as apart from other fields of education; it should mesh with all other learning. If we point a finger of scorn or ridicule at other fields of learning it may be a sign of inadequacy on our own part."

Professor Saxton made the following appointments: J. C. Davis, University of Oklahoma, Chairman of the Program Committee. G. P. Stocker, University of Arkansas, and Professor Wood, Oklahoma A. & M., members of the Program Committee. C. A. Dunn, of Oklahoma A. and M., Chairman of the Committee on Arrangements, with Professor Stelzner, University of Arkansas, and Acting Dean F. G. Tappan, University of Oklahoma, as members of the committee.

L. A. Comp,
Secretary

The following paper was presented before the **Kentucky Section** at its meeting on April 16, 1936.

IMPROVEMENT OF ENGINEERING TEXTBOOKS

By Jean M. Roberts

Associate Professor of Electrical Engineering, University of Louisville

Within the past few years "The Textbook Question" has been considered in some of the meetings and conferences of the Society for the Promotion of Engineering Education, and several articles have been published on the subjects. (H. H. Higbie, "Some Educational Objectives in the Writing of Textbooks," The Wiley Bulletin, Nov., 1934; S. A. Moss, "Symbols Standardization," JOURNAL of S. P. E. E., Jan., 1932, page 371; R. C. Brinker, "The Textbook Question," JOURNAL of S. P. E. E., Mar., 1935, page 475; etc.) Many specific suggestions for improving textbooks have been given in these articles, but the actual improvements have not yet appeared in many of the engineering books. Textbook writing was very briefly discussed and criticized in the S. P. E. E. Report of the Investigation of Engineering Education (page 293, Volume I; and pages 1095, 1097, and 1099, Volume II), but a much more thorough study of this subject should be very profitable to the engineering schools of this country, and I believe that the Society for the Promotion of Engineering Education and the major engineering societies should take official interest in the problem. The object of this paper is to propose a plan for "Coöperative Writing of Textbooks" as a means of securing the desired improvements more quickly.

In the field of electrical engineering there is a considerable duplication of effort in the writing and publishing of textbooks, and judging from the number of textbooks published annually on other engineering subjects, it is apparent that a similar situation exists in the other branches of engineering. It is my opinion that the textbooks in a large number of engineering subjects could be greatly improved by more coöperation and less competition among authors and publishers. This statement applies to those textbooks that involve very little original authorship except in the wording and arrangement of the wellknown facts and principles they present. It is not intended to apply to textbooks dealing with highly specialized subjects or new material produced by research on the part of the author.

In order to make my meaning clear I have chosen this specific example: There are five or more recent books covering the general principles of electrical engineering designed for use in introduc-

tory courses for students of electrical engineering or in courses for "non-electrical" engineering students. (Books by Cook, Gray & Wallace, Blalock, Loew, Benton, Dawes, Morecroft & Hehre, Shepardson, etc.) Each of these books has some superior and some inferior features, and it seems evident that *one* excellent introductory textbook of electrical engineering, better than any of these now existing, could be produced if the authors would cooperate in combining the best features of all of these books into one ordinary sized volume. The contents of the composite book should be carefully checked by all the authors to insure the accuracy and clearness of every detail before publication. Also the book should be revised as frequently as necessary to keep it up to date and to make any improvements suggested by actual teaching experience. Because of the large edition expected for this improved volume the price should be less than that of existing textbooks, thus providing a further benefit to the students. While this example applies to an electrical engineering textbook, very probably there is a similar situation with respect to the textbooks used in several other undergraduate courses, such as applied mechanics, engineering drawing, and mathematics, and I believe that the textbooks for these and for many other subjects could be improved by the coöperative effort of several authors.

In the preparation of such a textbook there are obviously involved a considerable number of difficulties (chiefly financial ones). Some of these difficulties and corresponding suggestions for overcoming them are as follows:

1. The authors and publishers (or copyright owners) of existing textbooks covering the particular subject considered would be afraid of the economic loss that would be expected to result to them individually if the new book were adopted in most of the engineering schools. To compensate for this loss, a part of the royalty on the new book might be divided among the original authors, publishers, and copyright owners approximately in proportion to the amount of material used from their respective books, so that they may be repaid (at least partly) for the loss of sale of the old books. Also the business of publication of such new texts covering a variety of subjects might be divided among several publishing firms in a satisfactory manner.

2. Several authors, preferably the authors of the existing textbooks, would have to coöperate in arranging the text material, and there would naturally be differences of opinion about the best method of presenting each topic. To improve this situation, a joint committee of the S. P. E. E. and the engineering society concerned might be appointed to select a capable editor for the work and to assist the several authors. The committee and the editor

should be able to plan with the authors the work of the revision so that the time of preparation of the manuscript would not be excessive. Questionnaires might be sent to teachers using the present textbooks in order to obtain majority opinions about content and arrangement of the new text. Any suggestions on ideas received from teachers and used in the new textbook should be acknowledged by appropriate footnotes, and references to the original sources of the old material should be given wherever possible.

3. The authors would have to be paid for their work on the new book, and for this purpose the remainder of the royalty might be divided among the authors in proportion to the extent of their contribution to the new text.

Other difficulties also may arise, but I believe that *all* of the obstacles could be overcome if the authors, publishers, and copyright owners would adopt an altruistic spirit in order to permit the use of the best material already published. As a matter of fact, there is at the present time a rather free exchange of copyrighted material among authors and publishers. It may be noted here that the primary consideration *should* be the improvement of the textbooks for the benefit of the students, and that the consideration of royalties and personal recognition for the authors *should* be secondary.

The idea of joint authorship is neither new nor untried, and has been found successful for some textbooks now in use. An outstanding example of the collaboration of several writers is a well-known textbook of physics ("A Textbook of Physics," edited by A. Wilmer Duff, with four other contributors). Sixteen members of the faculty of a large university worked together to write a textbook for use in a general science "survey course" ("The Nature of the World and of Man," University of Chicago Faculty, H. H. Newman, editor). There are usually a large number of contributors for a comprehensive engineering handbook, since one engineer could not be expected to have all of the knowledge necessary to write a complete handbook covering one of the major branches of engineering. The coöperative plan of authorship here proposed differs in some respects from the cases of collaboration just mentioned, because the question of copyrights is involved and a greater degree of continuity and uniformity in the style of writing would be needed for an engineering textbook. However, the general principles involved in the preparation of a science text or a handbook should be similar to those involved in the coöperative authorship of an engineering textbook.

In this paper I have tried to emphasize two main points: first, that there is a need for an improvement in engineering textbooks, especially for the basic engineering courses; and second, that a

coöperative plan of authorship should be a practical means of producing the desired improvement, and at the same time should eliminate most of the economic waste resulting from the competition of *similar* textbooks. I further believe that the improvements expected would fully justify the effort required to put the plan into operation. If the results of combining and rewriting the existing textbooks should prove successful, it might be desirable to have standing committees for the purpose of preparing the future new textbooks in all branches of engineering. However, a more complete investigation of the subject of textbook writing, as previously suggested, will be necessary before definite conclusions can be reached concerning the feasibility of this coöperative plan of writing.

Missouri Section.—Following the registration of 95 members and guests at the Women's Building at Washington University, St. Louis, and during the course of the informal dinner for members and guests, the fifth annual meeting was called to order April 17, 1936, President E. O. Sweetser presiding. He expressed his appreciation of the fine services rendered by the local Committee on Arrangements, also for the esteemed assistance of Vice-President Clair V. Mann.

George R. Throop, Chancellor of Washington University, welcomed the members and guests.

The chairman appointed a Nominating Committee consisting of Professor C. E. Bardsley of Rolla, Professor F. A. Berger of Saint Louis and Professor A. C. Lanier, Chairman, of Columbia.

The following program was presented:

"What Lies Ahead in Engineering Education"—
From the Standpoint of the Student, Charles Fulton, Director, Missouri School of Mines;
From the Standpoint of the Teacher, F. Ellis Johnson, Dean, University of Missouri;
From the Standpoint of the Public, A. S. Langsdorf, Dean, Washington University.

Saturday morning, April 18, the open meeting of the Section convened in the Crow Hall Auditorium, Washington University, and was called to order at 10:00 A.M., President E. O. Sweetser presiding.

The recommendations of the Nominating Committee were called for. Professor A. C. Lanier, Chairman of the Committee, reported as follows: for President, Dean F. Ellis Johnson; for Vice-President, Professor T. R. Ball; and for Secretary, Professor I. H. Lovett. The nominees were elected by acclamation.

The chairman announced the desire for suggestions regarding a repository for the records of the Missouri Section. Mr. H. H. Armsby of Rolla tendered the use of his office files.

The chairman introduced the following prominent engineers of Saint Louis on the speaking program:

"What Can the Chemical Engineering Profession Expect from the Chemical Engineering Graduate?" Jules Bebie, Consulting Chemical Engineer.

"Engineering Education From the Employer's Viewpoint," Colonel Fred W. Green, Vice-President, St. Louis Southwestern Railway.

"What Has Been Our Experiences With College Graduates?" Hermann von Schrenk, Consulting Timber Engineer.

This was followed by a brief discussion led by Vice-President Clair V. Mann. The meeting concluded with an informal luncheon in the dining room of McMillan Hall, Washington University.

J. R. WHARTON,
Secretary

ENGINEERING EDUCATION FROM THE EMPLOYER'S VIEWPOINT

BY FRED W. GREEN

Vice-President, St. Louis Southwestern Railway

An invitation to address a group of college professors who have dedicated themselves to engineering education is a rare privilege. We live in an age in which a substantial number of our citizens believe that whatever is, is wrong. As a people we couldn't be happy without our illusions. We like to believe in Santa Claus, the Townsend Plan and other forms of economic magic. This is one of the major problems of education. A consciousness of ignorance is the first step in knowledge. To the ordinary individual, as well as to the minority blocs, it is just as easy to discharge the obligations of citizenship, as it is to understand the lofty concept of the Rights of Man. Because of these things we are the cockiest people on earth. The problem of engineering education, like the problem of all education is one of herd psychology. Members of boards of education should be selected because of their ability efficiently to serve the cause of education rather than because of their political popularity.

Primary education in our public school system is too far away from educational direction and control, and too close to politics.

A flippant way of describing it as a sort of Mother Hubbard which covers everything and touches nothing, is lacking in elegance but conveys the idea.

It seems to be a more or less generally accepted idea that the education of a child in the public school system consists in sending him to school for the number of years prescribed by the course. The inoculation having been made and the period of incubation having passed, there seems to be no doubt about the success of the process. But if a high school graduate takes the College Entrance Examination Board examination, he comes face to face, for the first time, with the coldly impersonal method by which there is objectively determined the quality and quantity of what he has learned. Instances have come to my personal attention, in which students sent to private preparatory schools, after failing the College Entrance examinations, have confessed that they were never taught and therefore did not know how to study until after admission to prep school. The old Hindu proverb is here apropos: "Study that you may learn, learn that you may understand; understand that you may know; know that you may judge." One of the first reforms in primary education should be the requirement that the student should be taught to study, through some sort of formal training, after he is old enough to appreciate in at least an elementary way, the necessity of proceeding from the unknown to the known, by invoking the processes of attention, interest, comparison, repetition and reflection. The necessity for the orderly array of facts, exactitude and rigor, and rational rather than emotional thinking should of course be stressed. If no small part of the undergraduate course in college must be devoted to the preparation of the student for college, the fault is not in the college teaching, but rather in the laxity of the primary school system. Much might be said upon this aspect, but this is neither the time nor place for it. And it must be admitted that the public school problem is in itself one not lightly to be disposed of, and whatever its faults, perhaps the major fraction cannot justly be attributed to those immediately charged with its administration.

In his introduction to "Human Intellect," Porter defines as educators "those who influence the character and conduct of their fellowmen, by public discourse or private conversation, by the persuasion of words or the magic power of look and gesture, those who seduce to evil, or win to good. . . ." While it must be admitted that athletic coaches "by the persuasion of words, or the magic power of look and gesture" have had great results in education in athletics, it is only fair to say that it is not difficult to find a suitable stimulus, namely adolescent aspiration for physical prowess. On the scholastic side, it is a major problem to find a

satisfactory stimulus. Perhaps a more generous distribution of memberships in Sigma Xi, and the honorary engineering societies might help.

But there is another aspect to the question of engineering education. It must fail if it is confined within the narrow limits of technology. While the student goes to college to become an engineer, it is the duty of the college to help him at the same time, to a better understanding of the world, to the end that he may live a useful life. "Education, as understood to-day, connotes all those processes cultivated by a given society as means for the realization in the individual of the ideals of the community as a whole. . . . It includes not only the narrow conception of instructions, to which it was formerly limited, but embraces all forms of human experience, owing to the recognition of the fact that every stimulus with its corresponding reaction has a definite effect upon character. It may be either mainly esthetic, ethical, intellectual, physical or technical, but to be most satisfactory, it must involve and develop *all* these sides of human capacity." (F. & W. New Standard Dictionary.)

In recent years the control of educational policies in our primary schools by politicians, has reflected the influence of mob hysteria. The inherent genius which politicians have for bungling in everything they undertake to regulate is well illustrated in the public school system to-day. Instead of a well-integrated series of curricula, consistent, coherent, congruent, we have almost the exact antithesis. The utilitarian has been over-emphasized and far more important factors ignored. Time belonging to education in its broader sense has been wasted in teaching enough to do much harm, but too little to do much good, of such subjects as hemstitching, typing, accounting, commercial art. Too often the end result is a graduate engineer, who has been taught to calculate stresses, make mechanical drawings, and perhaps even rectify the ellipse by the use of an elliptic integral of the second kind, who murders the King's English, has very little cultural background, and consequently is ill prepared to Live a Life.

How can engineers hope to be identified as members of a learned profession, if their educational background is so deficient in cultural subjects? To the utilitarian mind, the mere asking of such a question is heresy. But it is not the function of the utilitarian mind to make the identification. It is the verdict of society which will determine whether the engineer shall be classed as a professional man or a high-class craftsman. But whether he is interested or not in any classification, it can hardly be denied that his professional standing will improve with his ability to speak English, to write clearly, to understand people, and how to get along with

them. If this be conceded, then does it not follow that at some time in his scholastic career, our engineering student should have acquired some understanding of at least some of the so-called cultural subjects? Quoting Bacon: "Histories make men wise; poets, witty; the mathematics, subtile; natural philosophy, deep; moral, grave; logic and rhetoric, able to contend." While it is a controversial subject, it is your speaker's profound conviction that there is a distinct difference in values from the standpoint of mental discipline, in the study of various subjects. The mind acquires proficiency in thinking by practice in thinking. Thus, the thinking incident to developing an understanding of indirect discourse, the ablative absolute, the supine and gerundive, and other forms of Latin grammatical construction, is not the same kind of thinking called for in developing the derivative of log or that called for in determining the botanical classification of a plant from its leaf, fruit, habitat, etc. The value of these studies as well as those in history, and the social sciences, is primarily in their mental discipline, their giving a broader outlook upon life, and their development of a rational critical faculty and some facility in its use. In the Odyssey Homer mentions "the glory of a firm capacious mind."

Engineering education in Continental Europe seems to stress the purely theoretical subjects at the expense of the more practical subjects. The underlying idea is that the student shall have a wider theoretical background, even though it leaves him poorly equipped when going out into the world upon graduation to earn a livelihood. In England the college training, while following the Continental method to some extent in providing a broad background of theoretical instruction, is based on the idea that upon graduation the student will become an engineering apprentice and there learn the more practical side of engineering work, especially in such items as mechanical drawing, testing of materials, learning how to use machine tools, and so on. In Continental Europe it is my impression that both the quality and quantity of primary education is superior to that in this country. During a residence of nearly two years abroad I ran across several instances which did not seem to be at all unusual of boys fourteen or fifteen years of age who had completed elgebra up through Newton's binomial theorem, simultaneous quadratic equations, plane and solid geometry, four years of Latin, elementary physics and chemistry, and three or four years of at least one and sometimes two foreign languages.

In this country our engineering education, generally speaking, appears to be a compromise between the Continental and the English plans. Whether this may be due to the inadequate prepara-

tion of engineering students before they take up university work, or to a lack of coördination between the primary and secondary educational systems, or to the fact that in a democracy where everything must be so delicately susceptible to political pressure that it is not considered expedient by university authorities to cull out students taking engineering courses who lack efficient preparation as well as a natural aptitude for engineering study, I do not know. I do know that the very highest quality of instruction can never make silk purses out of sows' ears. I have the impression also that perhaps our engineering courses reflect the inevitable compromise inherent always in a democracy and in attempting to satisfy insistent demands for turning out of our universities upon graduation engineers who will at one and the same time be qualified to work as professionally trained engineers and as skilled artisans. Admittedly, the problem is difficult. Some years ago some of the universities provided five-year courses. This would undoubtedly be helpful, but my own view is that perhaps a better plan would be to abandon the idea of welding the wooden handle to the pewter spoon by revamping and supplementing the present courses to provide for two kinds of graduates: first, the skilled artisan type; second, the purely professional type, who, after graduation and somewhat after the English system, might be apprenticed in the particular branch of work which he might enter and while there acquire whatever additional training the particular type of work might call for. In the first category —the artisan type—time would thus be available for more thorough training in craftsmanship. These students would have more time available for acquiring an elementary knowledge, at least, of industrial management, business economics and the management of men. In the second category more time would be available for more intensive training in so-called cultural courses and more especially those which tend to develop imagination, resourcefulness and practical ways of attacking unfamiliar problems. In my own experience I have encountered instances which convinced me that there is a real need for training of this kind.

In closing, I can do no better than quote the following paragraph from Alderton Pink, an English writer, from his book entitled "A Realist Looks at Democracy":

"It is for no narrow political motives, but for the good of humanity at large that we must provide every possible educational facility for exceptional talents, in whatever social stratum they may be found. Original ability must be sought out, fostered, and given the chance to work for the good of our civilisation. We are already doing something in this direction through our system of scholarships and maintenance grants. But at

present our policy is so tinged with the democratic fallacy which would make all our geese into swans that much of our activity is unwise and abortive. In our schools and our universities we are heavily subsidising the education of many who have mediocre and even inferior capacity, and we are thus not only wasting effort but we are creating serious economic and other difficulties. The sort of schooling which issues in a course of university character should be made as efficient and as accessible as possible, but it should be reserved for those of real intelligence, so that our institutions of higher education may be filled with students who are fit to make a definite contribution to the solution of our critical problems."

Ohio Section.—Sixty-five members and visitors registered at the Annual Meeting of the Ohio Section held at Case School of Applied Science, Cleveland, April 18.

The program, planned by K. O. Thompson, Case School of Applied Science, Chairman, Max Robinson, Fenn College, and Walter F. Brown, University of Toledo, Vice-Chairmen, 1935–1936, follows:

MORNING SESSION IN BINGHAM LABORATORY

10:00 Welcome .....President W. E. Wickenden
10:20 Guidance in Engineering Education..J. Kopas, Fenn College
11:00 Correlation of Mathematics and Physics with Mechanics and Engineering ..... S. B. Folk, The Ohio State University
11:20 Discussion:

Clarence R. Wylie, The Ohio State University
Richard Burington, Case School of Applied Science

11:50 The Theme of the Madison Meeting in June.
Sada Harbarger, The Ohio State University
12:30 Luncheon at the Case Club, Deering Avenue

AFTERNOON SESSION IN THE CASE CLUB

2:00 Business
2:10 The Non-professional Preparation of the Engineer.
G. C. A. Hantelman, Goodyear Industrial University
2:30 Discussion
3:00 Adjournment

The officers elected for 1936–37 are: Chairman, Harold W. Bibber, The Ohio State University; Vice-Chairmen, Ross C. Durst, University of Akron, Clyde W. Park, University of Cincinnati; Secretary, S. A. Harbarger, The Ohio State University.

S. A. HARBARGER,
Secretary.

The **Pacific Northwest Section** of the Society met for its fourth annual meeting on the campus of the University of Idaho on Friday and Saturday, April 24 and 25, 1936. Registration was as follows:

University of Washington, Seattle	20
State College of Washington, Pullman	18
Oregon State College, Corvallis	6
Montana State College, Bozeman	3
University of Idaho, Moscow	25
Total	72

In conjunction with the trip to the meeting, a considerable number of the group included visits to Coulee Dam and Bonneville Dam now under construction on the Columbia River.

The first meeting was held Friday evening at 6:30 at the Hotel Moscow. Approximately 70 were in attendance at the business and technical meeting. A review of engineering activities in the Northwest was presented as follows:

Bonneville Dam, Professor S. H. Graf, Oregon State College.
Coulee Dam, Professor Homer J. Dana, State College of Washington.
Ft. Peck Dam, Professor L. D. Conkling, Montana State College.
All presentations were accompanied by illustrations.

The combined invitation of Montana State College, Bozeman, and Montana School of Mines, Butte, to hold the fifth annual meeting in Montana in 1937 was accepted. The following officers were then elected: Chairman, L. D. Conkling, Montana State College; Vice-Chairman, Francis A. Thomson, President, Montana School of Mines; Secretary, Merrill R. Good, Montana State College.

On Saturday morning from 9:00 to 10:30, the delegates were taken on an inspection tour of the University of Idaho. They then traveled in cars the nine miles to Pullman, Washington, and inspected the State College of Washington campus from 11:00 to 12:30, following which all gathered for luncheon at the Washington Hotel, Pullman. Dean H. V. Carpenter made a short speech welcoming the members. Professor E. B. Parker of the State College of Washington was toastmaster. At 1:30 P.M. the delegates started for Moscow for a technical session. This meeting was held in Science Hall from 2:00 to 4:15 P.M. Secretary J. E. Buchanan presided.

PROGRAM

"Summer Courses in Surveying and Shop"—Should they be inaugurated by schools of this area?
Frederic C. Welch, State College of Washington,

Gilber S. Schaller, University of Washington,
G. E. Hawthorn, University of Washington.

"Applied Economics for Engineers"—What shall be included and what teaching methods are applicable?
Merrill R. Good, Montana State College.

Discussions by:
H. J. McIntyre, University of Washington,
C. A. Mockmore, Oregon State College.

The annual banquet was held Saturday evening at the Hotel Moscow with Chairman R. H. Hull, University of Idaho, presiding. This was an informal dinner for members and ladies. A few entertainment features were presented by the University of Idaho Music department. Dean Ivan C. Crawford, University of Idaho, who is a member of the E. C. P. D. committee on accrediting colleges of engineering addressed the meeting on the subject: "Accrediting Colleges of Engineering."

J. E. BUCHANAN,
Secretary.

SUMMER SURVEYING CAMPS

By FREDERIC C. WELCH

State college of Washington

For years there has been an increasing tendency on the part of Deans and Heads of Departments to rather look down the nose at the courses in surveying and decry their importance in the modern scheme of engineering education. Usually the teching of these courses is relegated to the newest and youngest member of the staff whose chief interest may lie along the lines of mechanics and structures and whose sole interest in the subject of surveying lies in the fact that it furnishes the necessary teaching experience to enable him to move on to other (to him) more interesting subjects.

With the coming of the depression in 1929 a large number of the younger men in the structural field found themselves out in the cold and with the coming of large public works projects as a work-relief program these men were forced to turn to almost anything they could find to keep the wolf from the door. Fortunately satisfactory planning of these large public projects requires maps and surveys on which to base estimates and so surveying came again to its own. The more courses you had had in surveying the better chance you had of landing a job. The Soil Conservation movement got under way and dozens of agricultural engineers suddenly found that their brief courses in surveying were inadequate to cope with

problems in topography and adjustment of instruments. The sum of all this shows that many from the fields of agricultural engineering, electrical engineering, and mechanical engineering are now taking further courses in surveying the better to fit themselves to the requirements of the present day.

Surveying is one of the first subjects in which the undergraduate comes face to face with some of the fundamental concepts on which engineering training is based. Heretofore he has been told, "Do it like this." I tell my men that it is a painful process but the time has now come when you must stand on your own hind legs and learn to think for yourself. The following excerpt taken from Professor Rubey's book, "Engineering Surveys," gives a clear, concise statement of the importance of the subject. "Surveying provides many phases of training in addition to the knowledge of surveys. It is probably the best review and application of the principles of geometry and trigonometry, these fundamental branches of mathematics most used in engineering practice. It provides training in the neat and systematic arrangement of notes taken in the field, a training that is equally applicable to the factory and to the laboratory; for training in long and systematic calculations which cannot be solved haphazard.—It is of the highest importance that a man should be absolutely honest. Akin to honesty is accuracy. Both are fostered by surveying. One must be absolutely honest and accurate in survey work not only with his associates but with himself. No mental evasion or play upon the weakness of humanity will cover up errors or make poor work check properly. Careful, painstaking effort resulting in definite material benefit cannot but make for the development of character." One of the most valuable things that a student discovers is that there is no answer in the book. He *must* prove his own work.

Surveying instruction on the campus is beset with increasing difficulties under present-day conditions. The large classes are particularly destructive of lawns, stakes and chaining pins are a menace to power mowers, and the extensive plantings of ornamental shrubbery while adding to the beauty and attractiveness if the campus ruin many a fine surveying problem.

On the campus the regular laboratory period of three hours is found to be wasteful of time. Too much time is spent in starting and closing the problem. Then, too, we have to follow too rigid a schedule. So many men, so many problems, so many days.

A summer survey camp located on the shore of some small lake far from the madding crowds is the answer to many of our difficulties. Work can start at 8:30 A.M., lunches carried in the field, one-half hour for the noon lunch, back to camp in time for a swim before dinner. Computation of field data or two hours supervised

study in the evening. In other words, a routine closely following that of an actual field party. No interruptions or notices from the president's office that "periods will be shortened fifteen minutes each today to hear Dr. X at a special convocation," etc. No distractions. Just a simple, healthy pioneer life out in the wilds under primitive conditions with plenty of work to keep everybody out of mischief. No overcrowded classes from a heterogeneous mixture of departments and colleges but a small, closely knit group having a common objective. Larger work units approximating actual work conditions. For recreation, swimming, canoeing, mountain climbing, exploring, a glorious six weeks to live in your memory as long as you live. You learn to pit your puny intellect against the mighty forces and laws of nature. See if you can wrest from her the secrets that are yours for the taking, if you are strong enough and skillful enough to take them.

For such a camp as I have described the location will need to be selected with considerable care. The site should be on a medium or small-sized lake, preferably *not* a summer resort. It should be near a good road but sufficiently isolated so that there will be no trouble from an over-supply of visitors. This will also curb the tendency for the frequent trips to town. It should, if possible, be in or near a forest reserve or a considerable area in public ownership. The country should be rolling or hilly with only scattering timber. Level open field near camp for base-line and star observations. A plentiful supply of pure, cold water is of prime importance. A small hydro-electric or Delco plant may be installed to furnish lights for the camp. In short the natural environment should be healthful, interesting, and somewhat primitive.

Now just a word as to how some of our colleges are meeting this situation. I have selected only a couple of examples each from the three main sections of the United States, the East, the Middle West, and the Pacific Coast.

In the east, Massachusetts Institute of Technology maintains a summer camp in surveying at Lake Machais, Maine. This continues for eight weeks immediately following commencement and is required of all Civils. Costs are: Tuition $100, Board about $60, Transportation and miscellaneous, about $40, or a total of $200; Harvard, an 8 weeks' camp at Squam Lake, New Hampshire. Expenses about the same as at M. I. T.

In the middle west: Iowa State College has maintained a summer camp for some 30 years. Camp is now on Rainey Lake in northern Minnesota and lasts for six weeks. Fees and expenses, Tuition $27.00, Mess $40.00, Transportation and miscellaneous, including inspection trip in St. Paul enroute $60.00, or a total of

about $110–125. The mess is handled at cost and a refund is made if any surplus remains at the end of camp.

The University of Michigan has maintained a summer camp since 1874. In 1929 the University purchased some 800 acres of land in the Jackson Hole country in Wyoming. This location on the Hoback River is some 1700 miles from the campus but furnishes an ideal site. It is close enough to the Yellowstone and Grand Teton National Parks to permit weekend visits. Distance has proved no handicap. The camp runs for eight weeks. Costs are from $125–150 divided as follows: University fee $42.00, Board $45–60; Transportation and miscellaneous make up the balance. Cost of transportation is based on 3–4 students traveling in one car. The average increase in cost for the distant camp is only about $15–20 per man.

On the Pacific Coast so far as I know only the University of California and U. C. L. A. maintain a summer camp. This is in the hills of Marin County near Fairfax, California. The camp is for four weeks but attendance is required in two different years or a total of eight weeks. Laboratory fee of $20.00 is charged, plus a commissary deposit of $40.00. Transportation and miscellaneous are up to the individual. No total estimated costs given, but as this breaks into two different summers the costs would approximate those of the University of Michigan with the added handicap of two summers' loss of work rather than only one.

Now that we have made a brief review of the practices of some of our four colleges similarly situated let us then consider the situation as it applies to us. I will limit my presentation to the conditions as they exist at the State College of Washington and at the University of Idaho. The two schools are so located and the courses are so similar that I find that the problems of one are practically the same as those of the other.

First, we find that there is a serious congestion on the campus of both institutions, due to the large classes in surveying. Traditionally Friday and Saturday are open nights for general college enjoyment. Consequently, a Saturday class is always small and at least one-half the men are dead on their feet. This narrows the work week down to five days. Also there is the traditional fetish that recitations should be held in the morning and laboratories in the afternoon although at Washington State we have been forced to the double shift in order to make our equipment go around. So far we have only had to carry the morning laboratories and afternoon recitations through the sophomore year. The students do not like it but from various tests that have been made by the Mathematics Department and myself we don't find that the morning laboratory and afternoon recitation offer any

serious handicap to the student. One thing that does cause a grumble, however, and I feel that the grumble is more or less justified, is that Forestry students, Mines and Geology, Agricultural and Chemical Engineers, due to their schedules, dominate the afternoon laboratories to the almost total exclusion of the Civils, Electricals, and Mechanicals, and 90 per cent of the latter group are forced to the morning schedules, willy-nilly.

For several years Washington State has scheduled four sections of plane surveying per year. One A.M. and one P.M. section each semester. The A.M. sections have an enrollment of 30–40 and the P.M. sections 50–60 each. In the fall we give a course in Railway and Highway Surveying required only of Civils but elected occasionally by Mathematics, Mining, and Electrical majors. Also an elective course in Field Astronomy and Geodesy that is sandwiched to fit the instructor's schedule.

In the spring semester we offer a course in Topographic Surveying that is required of Civils, Hydro-Electricals, and Foresters, and is elected by Mathematics majors, Electricals, Mechanicals, Mines and Geology, Agricultural and Chemical Engineers. Enrollment totals from 50–80. The courses in Topographic and Railway surveying are the ones that give us the most trouble from an operational standpoint. Space is required. Even if we stick to college-owned land about the time we get ready to cross-section or triangulate we find our stakes either plowed out by the farmer or pulled out by the school kids. If we cut across private land someone carelessly leaves a stake in an alfalfa patch and you can guess the consequences. Both to the farmer and to us.

In view of the above conditions I would like to propose the following setup of surveying courses:

(1) On the campus:

(*a*) Plane surveying; 3–4 hours. Either 2 recitations and one 3-hour laboratory or 2 recitations and 2–3 hour laboratory periods per week given as now to all who wish to risk it.

(*b*) Topographic Surveying; 3 hours, for non-engineer students. 1 recitation and 2–3 hour laboratory periods per week. Less technical than our present 4-hour course. Not open for engineer credit.

(2) In Summer Survey Camp operated jointly by Washington State College and University of Idaho.

(*a*) Combine the present courses in Topographic Surveying and Field Astronomy, add some Hydrographic Surveying and Stream Gauging. Credit 4 hours. Required for Engineer Credit. Prerequisite: Plane Surveying and Junior or Senior standing.

(*b*) Railway and Highway Surveying. 4 hours. The equivalent of W. S. C. courses, C. E. 103 and 125, or U. of I. courses C. E. 107 and 113.

Such a camp lasting for six weeks immediately following Commencement could easily cover more than we can give in the regular scheduled courses now given as recitations and laboratories on the campus.

As a daily program I would like to suggest the following:

6:00 A.M.	Rising bugle.
6:30 A.M.	Breakfast.
7:15 A.M.	Recitations and Instructions.
8:00 A.M.	Field.
12:00 Noon	Lunch.
12:30 P.M.	Field again.
5:00 P.M.	Return to camp. Daily swim.
5:30 P.M.	Dinner.
6:00 P.M.	Rest.
7:00 P.M.	Computation of day's work, study, star observations.
9:00 P.M.	Campfire assembly (occasional). Instruction in First Aid, camp sanitation, etc.
10:00 P.M.	Lights out.
Saturday	Half holiday.

Judging by the present enrollment at the State College and the University an enrollment of from 40–60 might be reasonably expected ineluding any properly qualified students from other schools or colleges who might be attracted to the camp. As to teaching load, I am a firm believer in the value of intensive personal instruction by experienced personnel. From my own personal experience both as a student and as an instructor I would recommend at least one instructor to each 8–10 students. There are so many ways of doing a thing incorrectly, and bad habits, once formed, are so hard to eradicate, that I am strongly convinced that active personal supervision is well worth the effort. You can read about how to do this, that, and the other, but when you get out there with an instrument or a rod five minutes personal instruction on the ground will go farther than hours of dilatory reading.

The general buildings of a camp should consist of a kitchen connected with a dining room, a computation hall and instrument room, and a storehouse. Housing for the students may be 4-man pyramid tents with board floors as at the Iowa State Camp on Rainy Lake or galvanized iron and concrete floors as at the Michigan camp in the Jackson Hole country.

If the camp is near a good road and the distance to the nearest hospital is less than 100 miles a camp physician can probably be

dispensed with provided some member of the camp faculty is experienced in First Aid. If on a lake several rowboats should be provided for general use of the camp.

A good mess is one of the strongest assets to any camp. Some member of the summer camp faculty should be designated as mess officer and at the close of camp should make a detailed report of receipts and expenditures. He should make a daily inspection of the kitchens and dining rooms and see that they are kept clean and sanitary. Food should be plain but well cooked and wholesome. The usual method of financing is to require a deposit of $40 to $60 paid before going to the site. The mess should be run at cost plus a small annual charge to cover breakage and to add to permanent camp equipment. With a $60 fee for an 8 weeks camp the University of Michigan has been able to rebate $10–$15 per student at the close of camp. This amount is sufficient in many cases to finance the trip home.

One of the first objections that will be made is that many of our students are from the poorer class and that they could not afford either the time or the money to attend such a camp. I do not find this a truly valid objection. Men continue to elect Advanced Military with its requirement of a six weeks' camp and there is considerable competition for the available places. The Department of Geology at Washington State has for years required a summer camp in that subject as a prerequisite for graduation. I have myself acted as instructor in surveying at some of these Geology camps and have felt that the boys learned more about surveying in the week to ten days that I had them out there in the wilds than they did in half a semester on the campus.

We are faced with this situation. The students are coming in increasing numbers. We must either multiply sections or take larger classes. As there is only space for so many sections in the work week the situation has been met so far by taking larger sections. My own experience is that the desirable size of a section is not to exceed 36. As we get larger sections the efficiency of teaching falls off according to the law of diminishing returns. Also either double sections at the same hour or larger sections require additional equipment. Transits and levels are expensive and require considerable upkeep. Within five years we will either have to modify our surveying courses and accept a lowered efficiency in our product or come to the summer surveying camp and attain increased efficiency.

The head of my department insists that I am one of those few darned freaks that really like to teach surveying. I admit it. Maybe I am. I still get a thrill out of inspiring one of my students to make a time observation off from the sun or a star and

check the error of his watch to the second or a series of azimuth shots that will check each other within one minute. You can talk your heart out and get only incredulous smiles but if you can demonstrate before their eyes that it can be done they will try to emulate the skill of the other fellow. What higher precision can there be than that demonstrated by Admiral Byrd—flying practically a straight line course from Spitzbergen to the North Pole and return. Or Harry Lyons' navigating of Kingsford-Smith's plane in the Frisco-Australia flight of 1928. It takes some accurate shooting to hit a dot of an island out there in the Pacific 3000 miles away and no factor of safety of 5 to save you if you make an error.

To sum up: Surveying *is* important. It furnishes employment to probably 75 per cent of our newer graduates. It furnishes valuable training in thought, habits, and method not only in surveying itself but other courses as well. Let us therefore not curtail instruction in this subject. Rather let us meet crowded campus conditions with the tried and proved methods of the survey camp. Live outdoors. Learn to take care of yourself in the woods and on the water. Watch the beaver build his dam. Surprise the graceful deer or the lumbering bear. Catch and cook your own fish. Spend a pleasant vacation and withal, incidentally, learn how to locate a highway; make a topographic map; find your latitude and longitude; know the stars.—A glorious six weeks of pioneering that you will remember all your life.

The second annual meeting of the **Southeastern Section** of the Society was held at the University of Alabama on April 7 and 8. The first session started at 7 P.M. as an informal dinner with approximately fifty members in attendance as guests of the University of Alabama.

Dean Floyd Field, chairman of the Southeastern Section, presided over the following program:

Welcome, G. J. Davis, Jr., Dean, College of Engineering, University of Alabama.

Informal Remarks, Geo. H. Denny, President, University of Alabama.

Response, Floyd Field, Dean, Georgia School of Technology.

Address, "How Good is My Engineering School?" Douglas S. Anderson, Acting President, Tulane University; President S. P. E. E.

John M. Gallalee, Professor of Mechanical Engineering, University of Alabama, took Dean Davis' place on the program as Dean Davis was prevented from attending due to illness.

Dr. Denny reviewed changes which have taken place in the entrance requirements and discussed some very interesting phases of the financial problems of Southern State Universities.

President Anderson's address centered about the problem of accrediting the smaller colleges of engineering. His paper created so much interest and discussion that a motion was passed to have it submitted to the publishing committee of the Society for consideration of publication in the JOURNAL, in an abridged form.* His address reviewed certain phases of the work of the Engineers' Council for Professional Development, with special attention being given to the problem of accrediting.

The second session convened at 9 A.M., April 8, with Dean L. J. Lasselle, Louisiana State University, Vice-Chairman of the Section, presiding. The program was as follows:

"Objectives and Materials of Engineering Education," by Professor S. P. Sashoff, Electrical Engineering Department, University of Florida.

"The General College and Its Effect on Engineering Education in the Southeast," a discussion led by Dean L. J. Lassalle, and Dean B. R. Van Leer, University of Florida.

Report of Committee on Five-Year Curricula, Dean B. R. Van Leer, Chairman.

Discussion of Plans for the National Meeting.

Business, election of officers, etc.

Professor Sashoff's paper set forth some interesting experiences and dealt largely with the re-adjustments which are necessary on the part of the student after graduation. He stated that, in his opinion, much could be done in engineering education to remove the necessity for so much adjustment, if the proper aims of engineering education were kept in mind. He stated, "The primary aim of education, it seems to me, should be to develop fully the potentialities of the student in order to enable him to help himself and the community in which he lives. To do this it will be necessary to (1) awaken intellectual interests and curiosity, (2) develop proper attitudes, (3) acquire the habit to study and to work, (4) create a sense of orderliness, discipline and honesty, and (5) learn such skills as may be necessary to fit into a profession."

The discussion led by Dean Lassalle and Dean Van Leer brought out that at Louisiana State University and at the University of Florida all freshmen are required to matriculate in a lower division or a general college and are not admitted directly to the College of Engineering. One essential difference between the

* Published in May, 1936, JOURNAL OF ENGINEERING EDUCATION.

plan at L. S. U. and Florida is that all students who wish to enter the College at L. S. U. may elect the necessary prerequisite subjects right from the start; whereas, at Florida only those in the superior group, which constitutes approximately the top 20 per cent, are allowed to do this.

Dean Lassalle stated the following advantages have come to the College of Engineering as a result of their lower division:

"(*a*) The Dean does not have to spend a great deal of time with freshmen on disciplinary and other matters, and so has more time to give to students who are really taking engineering subjects.

"(*b*) The number of students taking technical courses is reduced and the average quality is raised.

"(*c*) As a result of part (*b*) our sections are smaller and students get more individual attention. Also there is more of an 'esprit de corps,' more of a feeling of homogeneity, in the College of Engineering than when there were a great many freshmen in it."

Dean Van Leer brought out that the General College of the University of Florida is the first of its kind to be started in any state university and that the program and organization of this General College are founded on the following basic assumptions and principles:

"1. That existing curricula of the various colleges of the University, exclusive of short courses, were designed solely to meet the needs of students who are expected to receive the degrees of these colleges.

"2. That the existing program of the first two years of the University did not effectively meet the requirements of approximately one-half of the students, who, for various reasons, drop out before they reach the upper division, and of approximately two-thirds who drop out before graduation.

"3. That the new program would provide a fairly uniform two-year arrangement which not only would meet the demands of the students who drop out but, also, by broadening the base of education, would meet more adequately the demands of students desiring to prepare for advanced study in the colleges and professional schools of the upper division; that the work, particularly of the first year, should be closely integrated; and that some student may be able to complete the requirements of the General College in less than two years, while others may remain with profit for a longer period.

"4. That the General College should be separate and distinct from the colleges and professional schools of the upper division; that while its work should be articulated with these units of the University, its tasks should be broader than the tasks of these units; and that it should not be unduly restricted by them in solving its problems or carrying out its operations.

"5. That since intellectual development is largely a matter of self-development, the program should be so formulated as to stimulate intellectual curiosity and to encourage independent work on the part of the individual students.

"6. That the progress of students in the General College should be measured in terms of abilities, understandings, appreciations, and skills, instead of courses passed and credit-hours accumulated; and that the passing of comprehensive examinations would excuse some students from certain courses, and vary the usual time for many others.

"7. That comprehensive examinations with a special board of examiners to take charge of the administration thereof, thus separating in execution the teaching function from the examining function, would be essential to evolving and putting into effect the new plan of the General College.

"8. That the mastery of the contents of certain comprehensive courses should be required of all students; that other comprehensive courses designed to prepare students for advanced study in the colleges and professional schools of the upper division should complete the offerings of the General College.

"9. That one of the purposes of the General College should be to provide vocational guidance to students. The 'guesses' which freshmen bring to the University concerning the occupations they have 'decided' to enter cannot be accepted as final, for many of such choices are mere whims which will be abandoned as the student matures.

"10. That a desirable terminus or honorable exit should be provided at the end of the second year for those students who do not go on into the colleges and professional schools of the upper division.

"11. That the unity realized in the establishment of comprehensive courses in the General College would eliminate much duplication and inefficiency.

"12. That the work of the General College should be articulated with that of the secondary schools; that the new curriculum would doubtless influence the high-school curriculum and that the near future may present us with high-schools' products entirely different in type from those we admit to the University at present."

Dean Van Leer further brought out that the average student is now required to take five years in order to secure his bachelor's degree in engineering; but that the superior student will still be able to complete all requirements in four years.

The report of the Committee on Five-Year Curricula brought out the following important points:

"(1) Alabama Polytechnic Institution, although its faculty appeared to be generally opposed to the program, has placed its aeronautical engineering course on a five-year basis.

"(2) Georgia School of Technology, although its faculty and administrative officers are also opposed generally to a five-year program, has placed its course leading to the Bachelor of Science in Architectural Engineering on a five-year basis.

"(3) The University of Florida, by adopting the General College idea for the first two years in the University, compelled an adoption of a five-year program in all instances except for superior students. The program at the University of Florida for the average engineering student will now be approximately as follows:

> For the completion of the work in the General College and the passing of all comprehensive examinations which involves approximately 76 credit hours, a student will be awarded the Associate of Arts degree which is a prerequisite for his admission to the College of Engineering.
>
> For the completion of 76 additional hours plus Summer Camp Surveying or summer shop work and Military Science, a total of 160 credit hours, a student will be awarded a Bachelor of Science in Applied Science.
>
> For the completion of approximately 36 to 40 additional credit hours, practically all of which is in his particular specialty, the student will be awarded the degree of Bachelor of Civil Engineering, Bachelor of Electrical Engineering, Bachelor of Mechanical Engineering, etc. For exceptionally brilliant and capable student who averages above a 'B' in the first two years, it is possible to complete and secure the Bachelor of Civil Engineering, etc., in four years. The average student will require five, but he has already been requiring five in the past."

The Section was fortunate in having Dean P. H. Daggett, Vice-President of the Society, and F. L. Bishop, Secretary of the Society, present at the second session.

Dean Daggett reported that the work of the Accrediting Committee of E. C. P. D. should be complete in the first and second sections this spring and that accrediting in the other five districts of the country should start next fall.

Dr. Bishop reported that President Anderson's topic for the annual meeting, "The Spiritual Adjustment of the Engineering Student" has created a great deal of interest and that we should look forward to a very fine meeting at the University of Wisconsin. He also stated that the Society is in a state of good health financially and otherwise. The meeting was closed after electing the following officers for 1936–37: Chairman, Dean S. B. Earle, Clemson Agricultural College; Vice-Chairman, Dean W. S. Rodman, University of Virginia; Secretary, N. C. Ebaugh, University of Florida.

N. C. EBAUGH,
Secretary

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

A Journal of Engineering Drawing: Professor Mann of Missouri School of Mines suggests for the consideration of the Division of Engineering Drawing the publication of a journal devoted to the interests of teachers of engineering drawing and related subjects. He is at work now on a proposal of somewhat definite character involving size, cost, method of financing, content, and the like.

A leading article on the teaching of drawing describing the methods in use at each member institution; an editorial; a short illustrated discussion of some problem of teaching; illustrated problems; book reviews; news comments on items of equipment and materials; personals; outlines of research projects; all these and other items will furnish ample material of interest. How to finance and manage such a worthy and worthwhile undertaking, therefore, becomes the major problem.

The suggestion should have the serious consideration of the division at its meeting in Madison.

End of the Year or *Examination Blues:* Teacher: "Define orthographic projection." Student: "If you are given a picture drawing the side, that you can see to consider the front view is the side, if looking at right angles at all points you can see the most of the object on the one side, is the side that you can see the most of the object from."

Teacher: "What kind of a cap screw is used to hold down the cover on the part shown on page 472? Student: "Filibuster."

Final Pet Peeve: From the official S. P. E. E. Emblem and Membership statement: "*Print* your name. . . ." From page 672, THE JOURNAL OF ENGINEERING EDUCATION: concerning the S. P. E. E. Emblem: "When ordering . . . be sure to *write* your name. . . ." Maybe, after all is said and done, *lettering* would be too much to ask an engineer to do!

On to Madison: Double Feature for one price! Summer School for Teachers of Drawing: June 19–21 inclusive; annual convention of S. P. E. E.: June 22–26 inclusive.

Editor's Note: Websters New International Dictionary defines the following words:

Letter, v.t., lettered, lettering; To impress with letters; to mark with letters or words, as a book.

Letter, v.i.; to make, write, or carry letters. *Rare.*

Write, v.t., wrote, written, writing; To set down with legible characters; to form for the conveyance of meaning; to inscribe on any material by a suitable instrument; as to *write* letters or figures.

Write, v.i.; To form characters, letters, or figures, as representative of sounds or ideas; to express words and sentences by written signs.

Print, v.t., printed, printing; To form in characters like those of type (other than script); as, a letter *printed* by a child before he has learned to write.

Print, v.i.; To make characters like those in type (other than script); or to make words or the like in such characters; as, to *print* with a pen.

CIVIL ENGINEERING DIVISION

FRED L. PLUMMER, *Chairman* — H. C. BIRD, *Secretary*
FRANK KEREKES — K. C. REYNOLDS
L. E. GRINTER — H. E. BABBITT

THE MADISON CONFERENCE

The Civil Engineering Division extends to all who are interested in the teaching of Civil Engineering, an invitation to attend and take part in the special discussions and inspections to be held by the Division at the University of Wisconsin during the Madison Meeting of the Society. A detailed copy of the program has been mailed to each member.

You will note that inspections include the famed Forest Products Laboratories, the Surveying Camp, the Hydraulic Laboratories, and the Sanitary Laboratories. It is expected that several small groups will be organized for special inspections.

The Division will conduct three general sessions during the meeting as follows:

(1) Technical Developments of Interest to Civil Engineering Teachers.
(2) Forest Product Laboratories.
(3) Teaching Civil Engineering Courses.

The first session will be opened by H. E. Babbitt of the University of Illinois. A general discussion will be followed by six group discussions and these in turn by inspection trips.

The second session following an address by C. P. Winslow, Director, will adjourn for a complete inspection of the Forest Products Laboratories.

President H. S. Rogers of Brooklyn Polytechnic Institute will open the third general session and will be followed by Frank Kerekes and Hale Sutherland. The general session will again be followed by six group discussions.

In addition to the technical sessions and inspection trips the Division will hold an informal luncheon Wednesday, June 24th. The Annual Dinner of the Division at which officers for the succeeding year are elected, will be held Wednesday evening at the University Club.

COLLEGE NOTES

Cornell University.—Professor Herman Diederichs, Director of the Sibley School of Mechanical Engineering and the holder of the John Edson Sweet Professorship of Engineering, has been named Dean of the College of Engineering at Cornell University to succeed Dean Dexter S. Kimball, who will retire on July 1st.

Professor S. C. Hollister has been appointed Associate Dean of the College of Engineering, effective July 1, in addition to his regular duties as Director of the College of Civil Engineering.

Professor Diederichs is regarded as an authority in experimental engineering, with special reference to the materials of engineering. His text book in collaboration with the late Prof. R. C. Carpenter, published in 1910, is a standard work in the field of experimental engineering. A monumental work on mechanical experimental engineering dealing with engineering instruments was published in 1931 with W. C. Andrae. Volume two of this series, dealing with testing of power plant apparatus, is now in preparation.

During his long association with Cornell, Professor Diederichs has maintained an active interest in student activities, particularly with the Athletic Association. Elected in 1907 as track advisor to the Association, he became president in 1913 and served until 1925. He was again elected president in 1932 and relinquished this post to become chairman of the Board of Athletic Control. The recent reorganization of Cornell's athletic program has resulted from the activities of the Board of which Professor Diederichs was chairman. In recognition of his many years of service to his Alma Mater as student, teacher, and administrator, the Class of 1935 last year designated him as "Cornell's Man of the Year" and dedicated its class-book to him.

Lehigh University.—Professor Bradley Stoughton, Head of the Department of Metallurgical Engineering at Lehigh University, has been appointed Dean of the College of Engineering at that institution. Professor Stoughton graduated in civil engineering at Yale University and in metallurgy at Massachusetts Institute of Technology. Following an experience in practical metallurgy, he served as instructor and associate professor of metallurgy at Columbia School of Mines 1902–8. After five years in private practice in metallurgical engineering, he served 1913–21 as Secretary of the American Institute of Mining and Metallurgical Engineers.

He came to Lehigh as Head of the Department of Metallurgical Engineering in 1923 after the death of Professor J. W. Richards.

Professor Stoughton's "The Metallurgy of Iron and Steel," first published in 1908, has been widely used in colleges and in industry; his numerous articles and sections in handbooks on iron and steel have had a marked influence on metallurgical practice. He has served many industries as expert and consultant; was a member of the jury of award of the Panama Pacific Exposition and head of the metallurgical division of the National Research Council.

Previous to his appointment by the Trustees on April 17, the faculty of the College of Engineering was presided over by a Chairman of the Council of the College of Engineering, elected for one year by vote of the faculty. The appointment of a permanent dean together with a more definite organization of the faculty is expected to foster a more effective coördination of departments and of college policies. The college of engineering at Lehigh includes the departments of chemistry and chemical engineering, civil engineering, electrical engineering, mechanical and industrial engineering, metallurgical engineering, mining engineering and physics. The University comprises two other colleges, namely, Arts and Science and Business Administration.

University of Michigan.—Professor H. C. Adams of the Department of Marine Engineering is conducting an interesting program of research to determine the efficiency of various methods of reducing and controlling the rolling of ships. He is employing electrical apparatus to determine the rate and amplitude of roll of the various models of standard ocean liners and freighters. He is securing results which are much more precise than those which have been obtained previously in other laboratories. He is hoping to be able to publish some of the results of his research in the near future.

Professor L. A. Baier of the Department of Marine Engineering is conducting research with several forms of ships and in different depths of water to determine the effect of shallow water upon resistance.

Professor J. Raleigh Nelson has resigned his executive position as Head of the English Department to give his full time to his work as Counselor to Foreign Students.

Professor Carl E. Burklund of the English faculty has been appointed this year on the Board of Awards for the Hopwood Prizes in Literature.

Professor Ivan Walton of the English Department is spending the year at the University of Chicago preparing his material for publication on Sailor Songs and Legends of the Great Lakes. He

has been accumulating this material for three years under a grant from the Graduate Research Fund.

The Department of Aeronautical Engineering has received a grant from the National Advisory Committee for Aeronautics to conduct an investigation of the qualities of a group of aluminum allow spars having quite dissimilar front and rear shear webs, for the purpose of establishing a suitable method of calculating the elastic axis. This investigation is under the supervision of Mr. B. L. Springer.

The Engineering Research has recently issued Research Bulletin No. 27 giving the results of research and the properties of metals at elevated temperatures. This investigation was made by C. L. Clark and A. E. White.

Villanova College.—Professor H. S. Bueche has received, for his Communication Laboratory, a 50-watt oscillator, of the type designed for aircraft communication. This addition will give the laboratory three high frequency oscillators with power outputs of from 5 watts to 500 watts. There has also been received from the Western Electric Company a central cable testing table and wire chief's switchboard. This board is equipped with necessary instruments for making Murray and Varley Loop tests on telephone lines.

The Mechanical Engineering Laboratory has just installed an air conditioner to give complete year around air conditioning. The apparatus will be used for student tests in connection with Professor J. S. Morehouse's course in Air Conditioning.

The Mechanical Engineering Laboratory has also received from the Buick Company a 1936 Buick chassis which will be used for Laboratory demonstration.

BOOK REVIEWS

Descriptive Geometry. Second Edition. C. H. SCHUMANN, JR., Associate Professor and Executive Officer, Department of Drafting, Columbia University. D. Van Nostrand Co., Inc., New York. 330 pages. Net price $2.75.

Professor Schumann's Textbook on Descriptive Geometry contains an abundance of illustrations and problems. In addition to the regular problem layouts, there are additional problems referring to these layouts, giving in all a total of 1800 exercises.

Considerable space (three chapters plus one on problems) is given to work on Points, Lines, and Planes. The remainder of the book deals with curved surfaces and intersections (both curved and plane surfaces). The first chapter on Introductory Principles and Problems is good. The author in this chapter explains very well these principles, using excellent illustrations and word descriptions.

W. IRWIN SHORT

Introduction to Physical Metallurgy. LELAND RUSSELL VAN WERT. New York. McGraw-Hill Book Co., Inc., 1936. 272 pages, $3.

The author states in his preface that this book "is an outgrowth of a course of lectures which I have given at Harvard University for some years past." That is how many of our best texts have originated; and he has succeeded in producing an excellent introductory book, and in making it about as comprehensive as can be expected in a book of the size.

After a brief introduction, seven chapters cover the following titles: I. What is a Metal? II. The Metals and their Properties. III. The Equilibrium Diagram; The Liquid = Solid Change. IV. The Equilibrium Diagram: The Solid = Solid Change. V. The Microconstituents of Alloys. VI. The Properties of Alloys. VII. The Mechanical and Thermal Treatment of Metals and Alloys.

Metals are defined, or described, on the "basis of the more obvious properties of the group." "The source of a metal's strength and plastic properties is found in its lattice structure, and in the manner of the bonding of the atoms in that lattice." In Chapter II, the further discussion of metals and their properties is taken up on the basis of the periodic table. It is continued with presentation of ideas of crystallinity, the crystal systems, and lattice

structures. Then follows a discussion of the ordinary use properties.

In the next two chapters the different types of equilibrium diagrams are described and explained in a simple, clear, and logical manner. For the most part the binary diagrams are used; but ternary diagrams also briefly explained. Near the end of these chapters the phase rule of Gibbs and the LeChatelier-Braun principle are briefly explained.

The microconstituents of metals and alloys are described and illustrated in a very satisfactory way; in detail such various items of structure as grain, size, shape and orientation, solid solutions, eutectics and eutectoids, dendrites, etc.

The mechanical, physicochemical and physical properties of alloys are presented under the main headings of Chapter VI. Frequent reference is made to the equilibrium diagrams, showing relationships, and the value and use of diagrams. A brief, but very good, section on corrosion is included.

The last chapter treats of the mechanical shaping both hot and cold, especially the internal mechanism of flow of the metal, and of the various thermal treatments and the internal changes during such treatments and their practical results.

The book is well written, and easy to follow, though occasional long and involved sentences are found. The individuality of the author shows up in many places in a very refreshing way. The tendency throughout the text is to treat the material from the fundamental standpoint of atomic arrangement and the results thereof. It seems to the reviewer that this book should prove to be a satisfactory teaching text.

S. L. GOODALE

Plane and Spherical Trigonometry. H. L. RIETZ, J. F. REILLY, AND R. WOODS, New York, The Macmillan Company, 1936. Revised Edition. $2.00.

There are several good features of this book that make it unlike many other texts on the same subject. The reviewer likes especially the introduction of only one important new idea at a time. For example, the authors define only the three principal trigonometric functions of an acute angle rather than the six functions of a general angle. After numerous examples to acquaint the student with the meaning of the trigonometric functions in Chapter I and after simple physical problems in Chapter II, the authors consider trigonometric functions of any angle in the following chapter.

Another excellent characteristic of the book is the fine miscellaneous exercises at the end of each chapter. Each list gives the student the opportunity to test his true understanding of the chapter. The introductory paragraph at the beginning of every chapter is certainly a good method of presenting the plan and giving unity to the book.

The second part of the book is devoted to spherical trigonometry and its applications.

This trigonometry contains the tables of functions and of logarithms that are essential to a course in the subject.

JOHN C. KNIPP

Advanced Algebra. P. H. GRAHAM AND F. W. JOHN, New York, Prentice-Hall, Inc., 1936. Revised Edition. $1.85.

In the revised edition of this book, there have been a few minor changes made. These are: in Chapters I and II, problems which were considered too difficult have been replaced by simpler ones (2) the Chapter on Complex Numbers has been changed from the third to the sixth; this new arrangement permits the Chapter on Logarithms to follow the one on Exponents and Radicals, a logical place for it (3) a better quality of paper makes the book much easier to read.

The main features of the first edition ought to be mentioned since they have been retained in the revised copy. Chapters I–IV may be considered review. Determinants are introduced in Chapter V so that the student has the chance to solve simultaneous equations by determinants from the beginning. Chapters VII to XVII deal with topics that are found in all college algebras and they are considered in the usual manner. Chapter XVIII, Selected Topics for Advanced Study, presents such subjects as Scale of Notation, Indeterminate Equations, Solution of the Cubic and Biquadratic Equation, Fundamental Operations. Thus interested students have a chance to extend the usual course.

There are numerous historical references scattered throughout the book. These references connect the subject with its historical background.

JOHN C. KNIPP

Materials of Engineering. HERBERT F. MOORE. Fifth Edition. McGraw-Hill Book Co.

No man is better qualified to write on the topic of Engineering Materials than Professor Moore, and the new edition of his well-known work should receive a hearty welcome.

The book is planned primarily as a textbook to give students a broad and comprehensive view of the questions involved in choice of suitable materials and of the principles to be followed in making such selections. The scope is very wide, covering such varied topics as properties of various classes of materials, methods of testing, physical structure, modes of failure and theories of the mechanism of failure, writing of specifications, etc. Covering such a broad field it is of course impossible to treat in detail all the various topics discussed. A large and well chosen number of references enable the reader to pursue further any special subject of particular interest. A series of questions on each chapter, printed at the end of the book serves to direct and concentrate the student's attention upon the essential points covered.

The chapters on crystalline structure of metals and on concrete are written by specialists in these fields—J. O. Draffin and H. F. Gonnerman.

The style is clear, concise and readable throughout, and is admirably adapted to the purpose of the book—to give students a broad general knowledge of this important field. The work is thoroughly scholarly without being pedantic or dogmatic. It should take its place as a very valuable text.

J. A. DENT

English in Business and Engineering. BRENTON W. STEVENSON, JOHN R. SPICER, AND EDWARD C. AMES. New York, Prentice-Hall, Inc., 1936. xiii + 365 pages. $2.25.

The authors of this book have designed a practical guidebook in English both for the practicing engineer and for the student. They have kept in mind the fact—one which is frequently overlooked—that the engineer needs as much facility in spoken English as he does in written English.

To satisfy the engineer's need for knowledge concerning the correct form and organization of business letters, the authors have devoted Chapters I and II to the requirements of the business letter in general and to the plan of specific types of business letters, such as letters of inquiry, letters of application, sales letters, etc. They have also devoted separate chapters to a discussion of the research article and the written report. For the business executive, they have included a chapter on the press release, indicating problems in press relations. A concise treatment of spoken English follows, with an additional chapter on logical thinking. The last three chapters of the book are concerned with the construction of the sentence, the paragraph, and the whole composition; the

preparation and correction of the manuscript; and a review of spelling, diction, and grammar.

In scope, the book is broad; yet each chapter is concise and illuminating. Enough up-to-date illustrative material is included, so that each principle is made concrete. To the engineer who thinks of English primarily as a collection of rules, the relegation of the chapters on grammar to the final section of the volume will be gratifying. He may sample them at will. By its variety of content, its clarity of presentation, and its practicality, the book should prove of value to the engineer who wishes to make his English more effective in writing and speaking.

W. GEORGE CROUCH

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G-E *Campus News*

X-RAY FOR ART'S SAKE

IS there a portrait of Great Uncle Ezra gathering dust in the attic? It may pay to x-ray Uncle before handing him over to the junkman, for behind Ezra's imposing whiskers may be hiding the sister of the Mona Lisa.

Not long ago, a portable G-E X-Ray Corporation unit disclosed a valuable canvas by the seventeenth-century artist, Goya, concealed under an apparently worthless picture. More recently a New Orleans painter and art expert has used the x-ray to discover a genuine da Vinci signature beneath layers of paint applied by a later and less-capable artist. A sister painting to the newly found da Vinci recently sold for a quarter of a million dollars.

The x-ray does more than discover lost Old Masters; it tells how the great artists of the past worked. A series of radiographs can disclose the full story of their brushwork from the first sketch to the last correction. The art student of today, by an intelligent use of the x-ray, is in a position to take lessons from the geniuses of the past.

MORE BRIGHT SPOTS ON THE GLOBE

THE mellow, golden-orange glow of sodium lighting is springing up all across the continent. The latest installation, the largest in the United States, is located in the state of Washington. Here sixty-six 10,000-lumen General Electric units line almost three miles of the four-lane Pacific highway between Tacoma and Fort Lewis.

Less than three years ago the sodium lamp made its first American appearance on a highway near Schenectady. Today the largest installation is on the Pacific coast, and the second-largest is at Lynn, Mass., on the Atlantic. In between, highways, bridges, traffic circles, and underpasses are being lighted for safety with these new luminaires, and G-E sodium lighting units have been installed in Canada, Hawaii, India, Spain, South Africa, Dutch East Indies, and Brazil.

NO CLICK!

THE life of the party, coming home with the milkman, need no longer fear the betraying click of the light switch if his house wiring includes the latest electric switch developed in the G-E Research Laboratory.

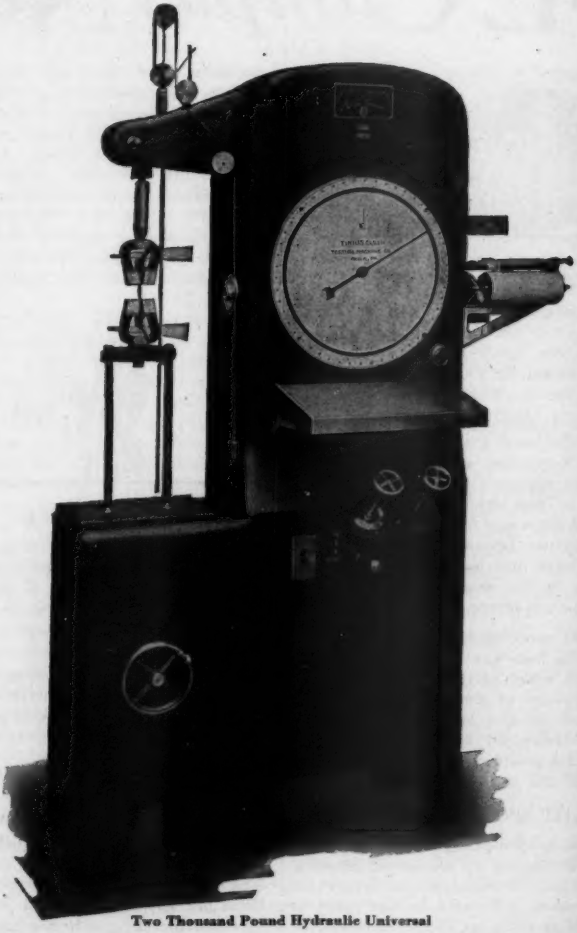
Two shallow chrome-steel cups, sealed together with a strip of glass, form the two contacts. A ceramic disk with a hole in it, and a few drops of mercury, partly fill the enclosure between the cups. The device is filled with hydrogen and sealed by welding. In the "off" position, the hole in the disk is above the mercury level. A rotation of twenty degrees to the "on" position permits the mercury to flow through the hole and make the electric connection.

The time-honored click of the switch is abolished. In the laboratory in Schenectady, one of these mercury switches has turned a 200-watt lamp on and off some 65 million times in the last two years, and there are no signs of wearing out or failure.

96-245FBI

GENERAL ELECTRIC

PRECISION - - - -



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